Life History Characteristics of Freshwater Fishes Occuring in British Columbia and the Yukon, with Major Emphasis on Stream Habitat Characteristics

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LIFE HISTORY CHARACTERISTICS OF FRESHWATER FISHES OCCURRING IN BRITISH COLUMBIA AND THE YUKON, WITH MAJOR EMPHASIS ON STREAM HABITAT CHARACTERISTICS

by

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ABSTRACT

Roberge, M., J.M.B. Hume, C.K. Minns, and T. Slaney. 2002. Life history characteristics of freshwater fishes occurring in British Columbia and the Yukon, with major emphasis on stream habitat characteristics. Can. Manuscr. Rep. Fish. Aquat. Sci. 2611: xiv + 248 p.

Associations between stream characteristics and different life history stages of fish were summarized for the 86 species and 13 additional subspecies and forms of freshwater fish that exist in British Columbia and the Yukon. Of the 99 freshwater species/subspecies, all but six occur in streams during part of their life cycle. Four habitat characteristics were summarized (depth, substrate type, cover type, and flow type) for four life cycle stages (spawning, young-of-the-year, juvenile and adult). Overall, there is a general lack of information pertaining to the stream habitat requirements for the many fish species that are found in BC and Yukon. In particular, research and information on stream habitat requirements is lacking for green sturgeon, minnows, smelts, ciscos, suckers, sculpin, lamprey, and stickleback.

RÉSUMÉ

Roberge, M., J.M.B. Hume, C.K. Minns, and T. Slaney. 2002. Life history characteristics of freshwater fishes occurring in British Columbia and the Yukon, with major emphasis on stream habitat characteristics. Can. Manuscr. Rep. Fish. Aquat. Sci. 2611: xiv + 248 p.

On a établi des associations entre les caractéristiques des cours d'eau et différents stades du cycle vital des 86 espèces et des 13 sous-espèces et formes additionnelles de poissons dulcicoles présentes en Colombie-Britannique et au Yukon. Quatre-vingt-treize de ces 99 espèces et sous-espèces dulcicoles passent une partie de leur cycle vital dans des cours d'eau. Quatre caractéristiques de l'habitat ont été examinées (profondeur, type de substrat, type de couvert et type d'écoulement) pour quatre stades du cycle vital (géniteurs, jeunes de l'année, juvéniles et adultes). De façon générale, on manque d'information sur les besoins des nombreuses espèces de poisson de la Colombie-Britannique et du Yukon en milieu lotique. En particulier, il n'y a pas assez de recherche et d'information sur les besoins de l'esturgeon vert, des épinoches, des ménés, des éperlans, des ciscos, des meuniers, des chabots, des lamproies, et des épinoches dans les habitats lotiques.

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INTRODUCTION

Population decline and species extinction occurs through over-exploitation, introduction of non-native species, and habitat and resource destruction (Slaney et al. 1996; Minns 1997). In fisheries, habitat destruction is particularly detrimental as fish dispersal to unaltered areas is restricted by the connectivity between areas and fish morphology. Fisheries and Oceans Canada is exploring methods of measuring, predicting and compensating for the affects of development projects that alter or destroy fish habitat (Minns 1997). Knowledge of the habitat use of fish species is vital to accurately assess and model the potential affect of proposed habitat alterations on local fish populations. In this paper, we summarize available information on the stream habitat use of fish species that are found in British Columbia and Yukon.

It was our goal to summarize the known habitat requirements of four life history stages (spawning, young-of-the-year, juvenile, and adults), and four habitat characteristics (water depth, substrate, cover, and flow) specific to each species found in BC and Yukon. Habitat requirements, as defined by Rosenfeld and Boss (2001), are the specific abiotic conditions which a species needs to survive, grow and reproduce. This paper attempts to present true habitat requirements, although in most cases only, habitat preferences or occurrence is available from the literature. For simplicity, habitat associations (encompassing requirements, preferences and occurrences) is the term used in this report.

Habitat information for all species listed in this report was not available for all life history stages or habitat variables, as the majority of the species found in BC and Yukon are not well studied. Because of the sometimes limited and obscure data available from BC and Yukon sources, habitat information was augmented by information from sources in other areas in North America or Europe and Asia. Where possible, specific studies done within British Columbia or Yukon are used.

Even though habitat association information is taken from multiple sources and areas, there are still major gaps in what could be presented here. Future research is needed to increase our knowledge base for many of the less understood freshwater fish species, and life stages.

METHODS

This report is the result of an extensive literature search for information pertaining to the stream habitat requirements of various life history stages of fish species occurring in British Columbia. The scientific name of each fish species follows Robins et al. (1991) (exceptions are noted in the text). The life history stages explored are spawning, young-of-the-year, juvenile, and adult. The spawning stage is when adults become reproductively active and move to a specific area to release gametes into the water for incubation. The young-of-the-year stage is the first year of life of the fish. It essentially begins once the fish has hatched from the egg and ends one year from that moment. The juvenile stage represents a fish older than one year that is like an adult in appearance, but is smaller and is not sexually mature. The adult stage is when a fish becomes sexually mature and has the potential to reproduce.

Databases searched include:

- Numerous reference texts and materials such as Carl et al. (1967); McPhail and Lindsey (1970); Scott and Crossman (1973); Morrow (1980); Groot and Margolis (1991); Ford et al. (1995); Cannings and Ptolemy (1998); Haas (1998); Bradbury et al. (1999).

- Refereed journals including Journal of Canadian Fisheries and Aquatic Sciences (Journal of Fisheries Research Board of Canada), Transactions of American Fisheries Society, North American Journal of Fisheries Management, Canadian Field-Naturalist.

- Bonneville Power Administration, Division of Fish and Wildlife, Portland, Oregon.
- Pacific Salmon Commission, Vancouver, BC.
- Ministry of Fisheries website and reference lists.
- Canadian Fisheries and Aquatic Sciences Technical Reports.
- Fisheries Technical Circular Reports.
- Campbell 1998 summary for COSEWIC (Committee of the Status of Endangered Wildlife in Canada).
- Interview with researchers (listed in Personal Communication section).

A written summary of the habitat requirements and general behaviours at each life history stage for each species and subspecies found in British Columbia is included. Major emphasis in the written summary is given to stream habitat requirements. Each written summary is accompanied by 1) a summary table located within the text that lists general stream habitat requirements and life history information, and 2) an appendix table that summarizes specific depth, substrate, cover and velocity requirements at each life stage.

GENERAL SUMMARY TABLE

The general summary table is included to give the reader an easy to read summary of the common stream habitat requirements and general life history characteristics of the species. Several habitat and life history parameters are included in the summary tables. These include:

- Stream/Ocean/Lake –location during life history stage stream (S), ocean (O), or lake (L);
- stream gradient – percent (%) slope;
- depth range – range of depths that the species inhabits (m);
- dominant substrate – substrate type which is used most commonly by species;
- dominant cover – cover type which is used most commonly by species;
- dominant habitat – habitat type (pool etc.) which is used most commonly by species;
- velocity range – velocities (m/s) in which species most commonly inhabits;
- turbidity range – turbidity range that species can withstand (NTU);
- oxygen range – optimum dissolved oxygen levels (ppm) for species;
- temperature range – optimum temperature (°C) for species;
- dominant prey – most commonly eaten food item or major prey species;
- duration – number of seasons, months, or years in which the specific life stage exists or occurs;

- size range – average size range of the life history stage (mm);
- age at maturity – age when adults become sexually mature (years);
- maximum age – life expectancy of the species.

APPENDIX TABLE

The appendix tables are included to present the importation of specific stream habitat requirements for each life history stage. Below is a detailed description of the habitat parameters included in the appendix tables, and the rating system.

WATER DEPTH

A total of five water depth categories are used, 0-20; 20-60; 60-100; 100-200 and > 200 cm. Depth represents the distance from the surface of the water downwards. For example, if a fish is found in large river systems but within the top metre of water, then 0-20; 20-60 and 60-100 cm is reported as the depth requirement for that species. Depth was reported exactly as stated in the reference, but if 'shallow' water was the only descriptor, a depth of 0–20 cm was used to represent 'shallow' water.

SUBSTRATE TYPE

Substrate composition was reported exactly as stated in the reference, however, if particle size was provided, substrate type was classified as follows: bedrock uniform continuous substrate, boulder = > 25 cm, cobble = 17-25 cm, rubble = 6.4-17 cm, gravel = 0.2-6.4 cm, sand = <0.2 cm, silt/clay = finer than sand with fine organic content, muck(detritus) = mud with course organic content, hard-pan clay = clay, and pelagic = open water, no substrate.

COVER TYPE

Cover is defined as 'features within the aquatic environment that may be used by fish for protection (or refuge) from predators, competitors and adverse environmental conditions (Bradbury et al. 1999).'

Cover is defined as:

- none – no cover:,
- submergent vegetation – aquatic plants that grow entirely below the water's surface (e.g. aquatic moss):,
- emergent vegetation – aquatic plants that are rooted within submerged areas, but the stem and leaves are above the surface of the water (e.g. cattail, reeds):,
- algae – aquatic algae that is present on the bottom or within the water column:,
- wood – large or smaller woody debris on the bottom or within the water column:,
- *in situ* – submerged cavities and crevices, undercut banks:,
- substrate – interstitial spaces between any size of substrate (boulder-sand):.

- overhead – cover originating in the riparian zone that overhangs the stream and/or stream banks, which includes overhanging riparian vegetation, woody debris outside the channel, or anything above the surface of that provides shade.

VELOCITY/HABITAT

Velocity or habitat refers to the type of habitat or channel unit that the species inhabits. These include:

- pool – velocity range < 0.25 m/s;
- run – velocity range 0.25-0.50 m/s;
- riffle – velocity range 0.5-1.00 m/s;
- rapid – velocity range > 1.00 m/s;
- river margin – habitat along the banks of the mainstem channel, often low velocity;
- off-channel –any habitat that is outside the mainstem flow including side channels, backwaters, and off channel habitats, often low or no velocity.

RATING SYSTEM

Association by each life stage with depth, substrate and cover features is rated using the following system.

- high (H) – species is nearly always associated;
- medium (M) – species is frequently associated;
- low (L) – species is infrequently associated;
- nil – species is not associated;
- blank space – no information was available to rate association;
- *italicized rating* – no information was available, however rating is based on association during a different life stage, on feeding/diet information and/or on lacustrine habitat association;
- grayed out area – the life history stage does not exist in freshwater.

RESULTS

A total of 86 species, two subspecies, and 11 forms of freshwater fish species from British Columbia and the Yukon were mentioned and/or summarized in this report. The subspecies/forms included in this report are unique to British Columbia and are of high conservation value (Cannings and Ptolemy 1998; Haas 1998), yet a total of four species are only found in the Yukon (Bering cisco, Arctic char, pond smelt, Arctic lamprey). This report mentions all the hybrid species that exist within British Columbia or Yukon, including the northern redbelly X finescale dace (Haas 1998), yet no summary of their habitat associations is included. Fifteen of the species are introduced to the area. All species included in this report are listed in Appendix 86. Figure 1 map highlights the major watersheds and rivers of British Columbia and the Yukon. Of the 99 species, subspecies and forms included in this report, all but six use streams for at least a portion of their life cycle, or the information pertaining to stream habitat use is minimal at best. Lake dwelling, or anadromous species use streams mostly as spawning habitat.

The times listed for spawning, egg incubation, emergence, movement between nearshore and offshore areas, and diel movements are approximate, and in many cases are based on laboratory experiments. Natural environmental variability in temperature, water depth, flow velocity and day length among locations and years will determine the exact timing of such events.

The following sections summarize the distribution and habitat associates of fish species and subspecies found in British Columbia and Yukon, with an emphasis on the stream environment. Within the text, the general stream habitat associations for each life stage of the species are given in tabular form. Following the text, appendix tables provide specific depth, substrate, cover and flow data of those species that inhabit streams for some part of their life cycle.

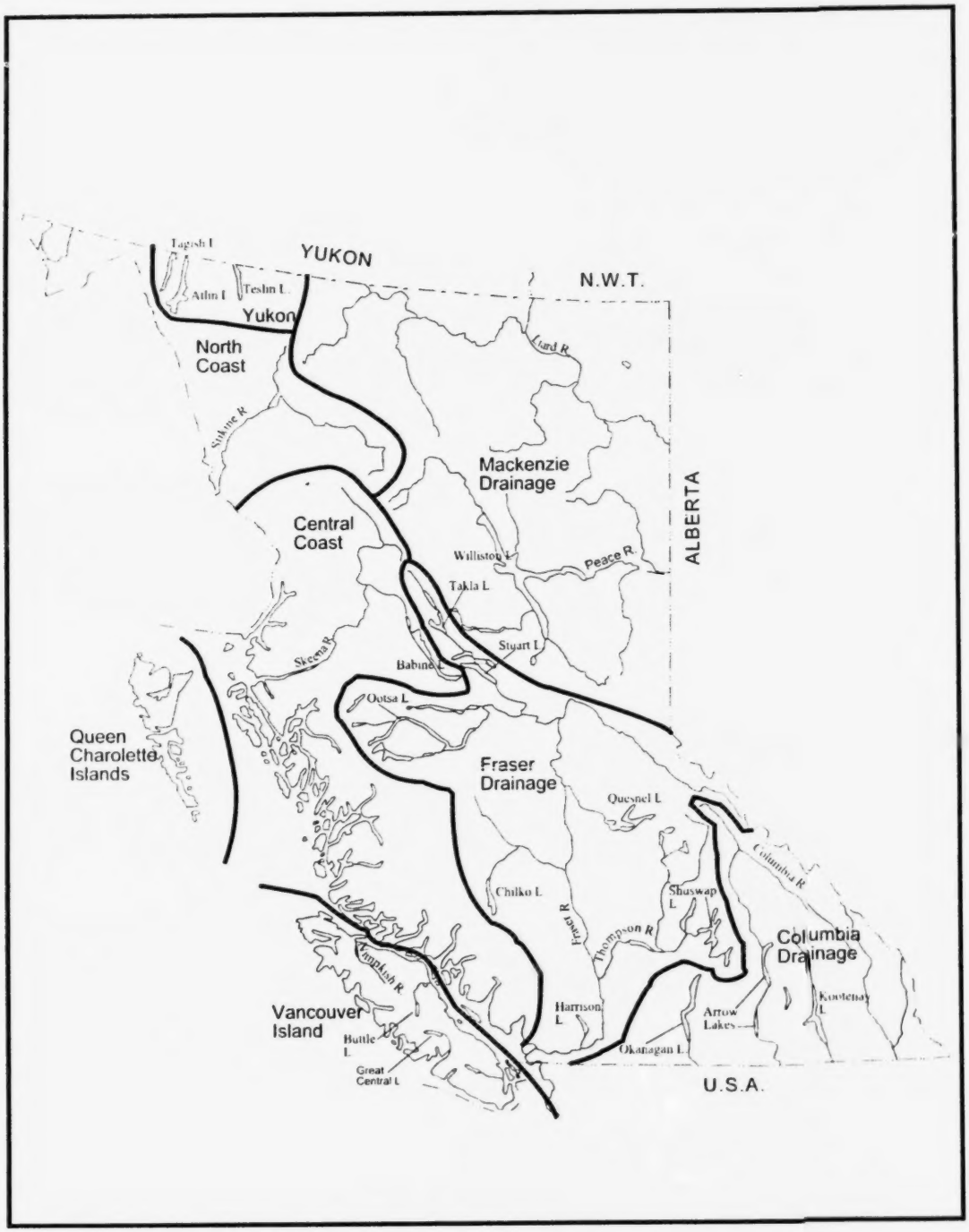

Figure 1. Map of British Columbia.

LAMPREYS (*PETROMYZONTIDAE*)

RIVER LAMPREY (*Lampetra ayresi*)

In 1958 the river lamprey of North America was described as a distinct species from the European river lamprey *(Lampetra fluviatilis)* (Vladykov and Follett 1958). The river lamprey is restricted to the Pacific coast of North America from the Skeena River, BC, to San Francisco Bay and the Sacramento River, California (Scott and Crossman 1973; Docker et al. 1999).

River lamprey are anadromous (Scott and Crossman 1973; Docker et al. 1999). They migrate up rivers to spawning grounds starting in July (Beamish and Youson 1987) and probably spawn over gravel (Scott and Crossman 1973) (Table 1; Appendix 1). In California they were documented spawning between the end of April and May. The ammocoetes burrow themselves in the mud of rivers and remain in freshwater for an unknown period of time after which they begin metamorphism into adults. Ammocoetes will feed on microscopic plants and animals while in the river (Scott and Crossman 1973). Metamorphism usually begins in July and may take until April to complete (Beamish and Youson 1987). River lamprey are parasitic (Docker et al. 1999), and feed on fish, particularly Pacific salmon and herring in the Strait of Georgia and lower Fraser River (Beamish and Youson 1987; Beamish and Neville 1995). River lamprey have also been caught in lake trawls in several BC lakes including Nimpkish Lake on Vancouver Island (Simpson et al. 1981), and Cultus, Kitsumkalum, Lakelse and Harrison lakes. Typical size of adult river lamprey ranges between 117 and 330 mm (Scott and Crossman 1973).

Table 1: Summary of stream habitat and life history characteristics of river lamprey.

	Spawning	Ammocoete	Adult
Stream/Ocean/Lake	S	S	O L
Stream Gradient	-	-	-
Depth Range	-	-	-
Dominant Substrate	gravel	mud	-
Dominant Cover	-	substrate	-
Dominant Habitat	-	-	-
Velocity Range	-	-	-
Turbidity Range	-	-	-
Oxygen Range	-	-	-
Optimal Temp. Range	-	-	-
Dominant Prey	-	microscopic plants	salmon, herring
Duration	April-July	unknown	metamorphosis July-April -
Size Range	-	-	117-330 mm
Age of Maturity	-	-	-
Maximum Age	-	-	-

ARCTIC LAMPREY (*Lampetra japonica*)

Arctic lamprey, as their name suggests, inhabit waters along the Arctic Ocean coast in North America, from the Mackenzie River and Great Slave Lake to north of the Kenai Peninsula (Scott and Crossman 1973). In the Yukon River drainage, Arctic lamprey occur upstream as far as the city of Dawson. In Asia, this species, and possible subspecies, are found from Norway to Pusan, Korea. Confusion exists as to the relationship between this species and its eastern equivalent the American brook lamprey *L. lamottei* (McPhail and Lindsey 1970).

Arctic lamprey are anadromous, however lake-dwelling populations occur in Tatlmain Lake, Yukon (YRR 2002) and other lakes. Arctic lamprey can be parasitic on fish (Scott and Crossman 1973). Lake-dwelling adults reach a smaller size than anadromous adults, who can grow up to 625 mm in length (Scott and Crossman 1937) (Table 2).

Spawning takes place in late-May to early-July in areas of moderate flow in the mainstem river when temperatures reach 12.2-15.0°C (Scott and Crossman 1973) (Appendix 2). Both sexes work to build the nest in gravel substrate. Eggs hatch within a few weeks of spawning. In the Slave River, larval Arctic lamprey were caught in drift samples in the lower reach of the river in early-June (Tallman 1996). The ammocoetes move to river margins to burrow in soft mud. It is unclear how long ammocoetes remain in the mud before metamorphosis. One researcher suggested four years (from Scott and Crossman 1973). Metamorphosis occurs between August and November, with ammocoetes transforming as they move downstream to the ocean or lake. The adult form only exists from metamorphosis to the next spring spawning.

Table 2: Summary of stream habitat and life history characteristics of Arctic lamprey.

	Spawning	Ammocoete	Adult
Stream/Ocean/Lake	S	S	O/L
Stream Gradient	-	-	-
Depth Range	-	-	-
Dominant Substrate	gravel	mud	-
Dominant Cover	-	substrate	-
Dominant Habitat	mainstem	river margin	-
Velocity Range	moderate	-	-
Turbidity Range	-	-	-
Oxygen Range	-	-	-
Optimal Temp. Range	12.2-15.0°C	-	-
Dominant Prey	-	microscopic plants	fish
Duration	May-July	possibly up to 4 years	metamorphosis: August-November
Size Range	-	-	150-625 mm
Age of Maturity	-	-	-
Maximum Age	-	-	-

VANCOUVER ISLAND (LAKE) LAMPREY (*Lampetra macrostoma*)

The Vancouver Island lamprey, also known as the lake lamprey, has only recently been considered a distinct species from *Lampetra tridentata*, the Pacific lamprey (Beamish 1982; Robins et al. 1991). This species is smaller than the Pacific lamprey and is non-anadromous (Cannings and Ptolemy 1998). The Vancouver Island lamprey has a very restricted distribution in only two lakes on Vancouver Island, BC, Cowichan Lake, and Mesachie Lake (Cannings and Ptolemy 1998; Docker et al. 1999), and do not enter streams during any part of their life cycle. Because of its limited distribution, COSEWIC (Committee of the Status of Endangered Wildlife in Canada) has listed the Vancouver Island lamprey as a vulnerable species in Canada (Campbell 1998), while the Conservation Data Centre (CDC) of British Columbia has listed Vancouver Island lamprey endangered or threatened (Red listed) (CDC 2001). Vancouver Island lamprey are parasitic (Docker et al. 1999) and feed on salmonids within the two lakes (Beamish 1984; 1987).

Both the Pacific and Vancouver Island lamprey exist in these two lakes, however Vancouver Island lamprey spawn in the lake while Pacific lamprey spawn in streams (Beamish 1982; 1984; 1987). Spawning of Vancouver Island lamprey has been documented in shallow areas over gravel at the mouth of several small creeks flowing into the lakes, but spawning may also occur in deeper waters. Spawning takes place during May to August with adults dying shortly afterwards.

Ammocoetes will live up to six years before transforming into adults between July to October (Beamish 1984; 1987). Adults become sexually mature two years after metamorphism, thus total life span is about eight years (Beamish 1984; 1987).

WESTERN BROOK LAMPREY (*Lampetra richardsoni*)

Western brook lamprey have a limited distribution. They are found in coastal streams in western North America from BC, including King Island and the southeastern corner of Vancouver Island, south to Oregon (Scott and Crossman 1973; Docker et al. 1999). In BC, western brook lamprey are found frequently in Cultus Lake (Scott and Crossman 1973). This species currently has a Red listing in BC (CDC 2001).

Western brook lamprey are non-parasitic and live in freshwater (Docker et al. 1999). Adults spawn between late-April to early-July (Pletcher 1963; Scott and Crossman 1973) at temperatures above 10°C (Pletcher 1963) (Table 3). Males make the nest in coarse gravel and sand at the heads of riffles in streams (McIntyre 1969) (Appendix 3). Eggs hatch within 15 days at 15°C (Pletcher 1963). Ammocoetes burrow in the mud and silt at the stream margins and remain there for up to six years (Pletcher 1963). They feed on microscopic plants while in the mud (Scott and Crossman 1973). Ammocoetes metamorphose into adults between August and November, and the adults do not feed (Pletcher 1963). Adults spawn and then die the following spring (Scott and Crossman 1973). Adults can range between 130-200 mm in length.

Table 3: Summary of stream habitat and life history characteristics of Western brook lamprey.

	Spawning	Ammocoete	Adult
Stream/Ocean/Lake	S	S	S/L
Stream Gradient	-	-	-
Depth Range	-	-	-
Dominant Substrate	course gravel to sand	mud	-
Dominant Cover	-	substrate	-
Dominant Habitat	head of riffles	river margins	-
Velocity Range	-	-	-
Turbidity Range	-		-
Oxygen Range	-	-	-
Optimal Temp. Range	>10°C	-	-
Dominant Prey	-	microscopic plants	do not feed
Duration	April-July	up to 6 years	metamorphosis: August-November
Size Range	-	-	130-200 mm
Maximum Age	-	-	-

PACIFIC LAMPREY (*Lampetra tridentata*)

Pacific lamprey inhabit Pacific coastal waters from the Aleutian Islands, Alaska to southern California (Scott and Crossman 1973; Docker et al. 1999). They are also present in Asia, ranging south to the Yuhutu River, Hokkaido, Japan (Scott and Crossman 1973). In BC, Pacific lamprey migrate far into major river systems, including the Columbia River and the Fraser River drainage to Shuswap Lake (Scott and Crossman 1973). They are able to move long distances upstream over obstacles such as rocks, dams and fish-ways by way of their suction disc (Scott and Crossman 1973).

Pacific lamprey are anadromous (Docker et al. 1999). Adults begin their upstream migration between July and September and migration continues to late-May or early-June the following year (Beamish and Levings 1991) (Table 4). Pacific lamprey do not become sexually mature until October to March (Scott and Crossman 1973), and spend between seven to nine months in freshwater before spawning (Beamish and Levings 1991). During this stream residency period, they hide under rocks and do not feed (Scott and Crossman 1973) (Appendix 4). Spawning takes place from April to July in headwater streams and rivers over sandy gravel at the margins of riffles. Pacific lamprey die soon after spawning, although some populations in Washington State are known to spawn more than once (Page and Burr 1991).

Eggs hatch within 20 days at 15°C (Pletcher 1963). Larvae emerge from the gravel within two to three weeks and move passively downstream to soft bottomed areas where they burrow in the silt, mud, sand, or leaf bottom (Pletcher 1963; Scott and Crossman 1973) and grow into ammocoetes. Ammocoetes spend up to four to six years in the mud before transforming into a parasitic adult which migrates downstream to the ocean or lake (Scott and Crossman 1973; Beamish and Levings 1991). Ammocoetes can range in size between 0.2-118 mm in length (Scott and Crossman 1973). Downstream migration is often initiated by an increase in stream discharge (Beamish and Levings 1991). In BC, lake-dwelling Pacific lamprey are known to be predators on fish (Carl 1953; Coots 1955; Pletcher 1963).

Ocean residency of adults lasts between 12 - 20 months before Pacific lamprey return to the stream to spawn (Scott and Crossman 1973). Off the BC coast, adults parasitize adult salmon (Birman 1950; Williams and Gilhousen 1968), and whales (Pike 1951). Adults reach between 122-682 mm in length (Scott and Crossman 1973). Pacific lamprey are in the adult form for approximately two-and-a-half years, and total life span lasts up to seven years (Beamish and Levings 1991).

Table 4: Summary of stream habitat and life history characteristics of Pacific lamprey.

	Spawning	Ammocoete	Adult
Stream Ocean Lake	S	S	O/L/S
Stream Gradient	-	-	-
Depth Range	-	-	-
Dominant Substrate	sandy gravel	mud, sand, silt, leaf	-
Dominant Cover	-	substrate	substrate during pre-spawning residency
Dominant Habitat	riffle margins	-	-
Velocity Range	-	-	-
Turbidity Range	-	-	-
Oxygen Range	-	-	-
Optimal Temp. Range	-	-	-
Dominant Prey	-	-	salmon, fish, small mammals
Duration	April-July	4-6 years	2.5 years
Size Range	-	0.2-188 mm	122-682 mm
Maximum Age	-	-	7 years

STURGEONS (*ACIPENSERIDAE*)

GREEN STURGEON (*Acipenser medirostris*)

British Columbia is the only province in Canada where green sturgeon are found. They inhabit brackish waters along the entire coast of BC, including Vancouver Island (Scott and Crossman 1973) and Queen Charlotte Islands (Slack and Stace-Smith 1996). The species is rare in freshwater (Scott and Crossman 1973; Haas 1998), and is infrequently seen in the lower Fraser, Skeena, Nass, Stikine and Taku Rivers (McPhail and Carveth 1993a). In the rest of North America, green sturgeon are found in coastal waters from the Gulf of Alaska to San Francisco Bay, California (Scott and Crossman 1973) and south to Baja, California (Morrow 1980). Green sturgeon are more abundant in Korea, China, northern Japan, and Russia to the Amur River then they are in North America (Scott and Crossman 1973), although they are listed as endangered in Russia (Artyukhin and Andronov 1990). Recently, COSEWIC listed green sturgeon as a vulnerable species in Canada (Campbell 1998), and in BC the CDC listed it as endangered or threatened (Red listed) (CDC 2001). This species is listed as rare in the United States (Birstein 1993).

There is very little freshwater habitat information available for green sturgeon. Their capture in salmon nets in the lower Fraser River during late summer and fall suggests they are an anadromous species (Scott and Crossman 1973). There is a small fishery for green sturgeon in the lower Columbia River (Van

Eenennaam et al. 2001). Nearly ripe adults were captured on the lower Klamath River in back eddies and along the shoreline of the river at depths between 3-6 m (Table 5; Appendix 5).

Spawning is assumed to occur during late June and July, however these records come from Asian populations (Scott and Crossman 1973). The only recorded spawning populations in North America are from the Klamath, Rogue and Sacramento rivers in California (Moyle et al. 1994). Mature females caught in the Klamath River range in age from 25-32 years and the mature males range in age from 18-30 years old (Van Eenennaam et al. 2001).

Table 5: Summary of stream habitat and life history characteristics of green sturgeon.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	O	O	O S
Stream Gradient	-	-	-	-
Depth Range	-	-	-	3-6 m
Dominant Substrate	-	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	back eddies, margins
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	-	-
Duration	June-July	-	-	female: 25-32 years old, male: 18-30 years old
Size Range	-	-	-	-
Maximum Age	-	-	-	-

WHITE STURGEON (*Acipenser transmontanus*)

White sturgeon are found in coastal systems from the Aleutian Islands to Monterey, California (Scott and Crossman 1973). White sturgeon inhabit coastal and inland rivers and lakes in BC. They are most common in the Fraser River and some of its major tributaries including the Harrison, Lower Pitt, Nechako, Stuart and Stellako rivers (Scott and Crossman 1973; Cannings and Ptolemy 1998). White sturgeon are also found in the Columbia and Kootenay rivers (Cannings and Ptolemy 1998). White sturgeon in and upstream of Kootenay Lake are isolated from other white sturgeon populations by the Bonnington Falls (Northcote 1973). Since 1994, this population has been Red listed in BC (RL&L 1999; CDC 2001), and listed as endangered under the United States Endangered Species Act (U.S. Fish and Wildlife Service 1999). White sturgeon from the main Columbia River, the Nechako and Fraser rivers are also Red listed in BC (CDC 2001).

White sturgeon are not anadromous but will sometimes venture into salt water (Lane 1991). They move into sloughs and side channels of large rivers like the Fraser River during summer in response to changes in temperature (Lane 1991) (Table 6; Appendix 6). When in lakes, white sturgeon are generally found near inlet and outlet rivers and creeks (Cannings and Ptolemy 1998). Kokanee salmon (*Oncorhynchus nerka*) are a major food source for white sturgeon (RL&L 1999).

Rising water temperatures and increasing runoff trigger spawning migration. In the BC portion of the Kootenay River system, adult white sturgeon migrate from Kootenay Lake and the lower Kootenay River to spawning areas near Bonners Ferry, Idaho (RL&L 1999; Paragamian and Kruse 2001). Males migrate two weeks before spawning, when temperatures reach 5.5-12.1°C, while females migrate a week later at slightly higher water temperatures (6.6-10.7°C). Throughout BC, spawning occurs in rivers during peak flows from May through August (Cannings and Ptolemy 1998; Parsley et al. 1993; Perrin et al. 1999), but as early as February in the Sacramento River (Kohlhorst 1976). Parsley et al. (1993) suggests that peak

spawning likely occurs at 14°C, although white sturgeon from the Kootenay River spawn at temperatures between 8.5-12.0°C (Paragamian et al. 2001), and in the Fraser River between 14.8-18.4°C (Perrin et al. 1999). Spawning temperatures were recorded between 15.5-19.0°C in the Upper Columbia, and to 21.6°C at the Pend d'Oreille-Columbia confluence (RL&L 1996). In the Sacramento River, spawning occurs at water temperatures between 7.8-17.8°C (Kohlhorst 1976), and up to 22.0°C (Stevens and Miller 1970). In the lower Columbia River, newly spawned eggs were collected at temperatures between 10-18°C (Parsley et al. 1993).

Females spend a shorter amount of time on the spawning grounds than do males (average 10.5 days and 30 days respectively, Paragamian and Kruse 2001). After spawning, the majority of female and half of the male white sturgeon in the Kootenay River system return downstream to Kootenay Lake, while the remainder move just downstream of the spawning grounds (Paragamian and Kruse 2001). These pre- and post-spawning migrations in the Kootenay River population can be as long as 200 km (RL&L 1999).

Appendix A of Perrin et al. (1999) provides an excellent summary of the physical characteristics of white sturgeon spawning habitat for the Sacramento, Columbia and Fraser river systems. White sturgeon spawn in moderate to extremely fast flowing and turbulent water in main channels (Kohlhorst 1976; Parsley et al. 1993; McCabe and Tracy 1993; Paragamian et al. 2001), but are suspected to also spawn in side channel habitat (Perrin et al. 1999). Turbidity on the spawning grounds can be as high as 14-30 NTU in the Fraser River, compared to 2.2-11.5 NTU in the Columbia River (Perrin et al. 1999). It is suspected that white sturgeon spawning sites are chosen based on a preferred velocity (Paragamian et al. 2001). In the Columbia River below the McNary Dam, velocity on the spawning grounds ranged from 0.5-2.8 m/s (Parsley et al. 1993), and in the Kootenay River velocity ranged between 0.5-1.8 m/s (RL&L 1996), and 0.2-1.0 m/s (Paragamian et al. 2001). In the lower Fraser River, surface velocity during spawning ranges between 0.7-2.1 m/s (Perrin et al. 1999). Spawning usually occurs in run habitat (Parsley et al. 1993; RL&L 1996; Perrin et al. 1999). Perrin et al. (1999), described spawning sites within the Fraser River as being in large eddies or areas with laminar flow without upwelling. Spawning in the Columbia River occurs at depths ranging between 2.0 – 24.0 m (Galbreath 1985; Parsley et al. 1993;). In the Kootenay River, spawning was observed at depths > 5.0 m (Paragamian et al. 2001). In the Lower Fraser River spawning usually takes place in water 0.5-3.3 m in depth, but can occur in water up to 10 m deep (Perrin et al. 1999).

Eggs are adhesive (Monoco and Doroshov 1983) and are probably broadcast (Lane 1991) over coarse substrate, such as gravel, cobble, boulder, bedrock, sand and silt substrates (Kohlhorst 1976; Parsley et al. 1993; RL&L 1996; Perrin et al. 1999; Paragamian et al. 2001). In the lower Fraser River, gravel substrate was found at the spawning locations, where it can be mixed with other substrates (Perrin et al. 1999). In the Columbia River, below the McNary Dam, the most frequently used spawning substrate was cobble and boulder, with only trace amounts of sand, gravel and bedrock included (Parsley et al. 1993). In the Kootenay River, white sturgeon spawn primarily over sand substrates (Paragamian et al. 2001). It is estimated that eggs drift along the bottom at a rate of approximately 0.5-1.0 km/day (Paragamian et al. 2001).

Larval sturgeon were found in the main channel and side channels of the lower Fraser River shortly after spawning in areas with a current velocity of 0.7-2.1 m/s, at average depths of 0.5 - 3.3 m but as deep as 10 m and water temperatures of 14.8-18.4°C (Perrin et al. 1999). Young-of-the-year white sturgeon from the Columbia River, were observed at depths > 9 m and velocities between 0.2 - 0.7 m/s (Parsley et al. 1993). Substrate used by young-of-the-year was primarily sand, but hard clay, mud/silt, cobble, gravel, and sometimes boulder substrate were also used. Young-of-the-year are 117-366 mm in length and they feed mostly on chironomids (Scott and Crossman 1973). Juvenile white sturgeon from the Columbia River were observed at depths > 4 m and velocities < 1.3 m/s (Parsley et al. 1993). Between the

Bonneville and McNary dams, juveniles were caught most often in the deepest portion of the channel (Palmer et al. 1988), in water > 9.1 m deep (McCabe and McConnell 1988)

Female white sturgeon mature much later than males. In California, males reach sexual maturity at age nine and females at age 13 - 16 years (Wydoski and Whitney 1979). In the lower Fraser River, the age of first spawning for females ranges between 11 - 34 years, while for males the range is 11 - 24 years (Semakula and Larkin 1968). Males spawn on average every two to five years, while females spawn every three to eight years (Semakula and Larkin 1968). White sturgeon can live over 100 years, reach 6 m in length and they feed on fish and crayfish (Scott and Crossman 1973; Cannings and Ptolemy 1998). Adults can inhabit water temperatures ranging between 0.0-23.3°C (Scott and Crossman 1973).

Table 6: Summary of stream habitat and life history characteristics of white sturgeon.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S/L	S/L
Stream Gradient	-	-	-	-
Depth Range	0.5-24 m	0.5-10 m	>9.1 m	-
Dominant Substrate	silt-bedrock	sand	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	main channel, side channels, back eddies, upwelling	main channel, side channel	slough, side and main channel	slough, side and main channel
Velocity Range	0.2-2.8 m/s	0.2-2.1 m/s	<1.3 m/s	-
Turbidity Range	2.2-30 NTU	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	peak: 14°C, 8.5-22°C	14.8-18.4°C	-	0-23.3°C
Dominant Prey	-	chironomids	fish	fish, crayfish
Duration	May-August	-	-	-
Size Range	-	117-366 mm	-	up to 6 m
Age of Maturity	-	-	female: 11-34 years, males: 11-24 years	-
Maximum Age	-	-	-	up to 100 years

MOONEYES (*HIODONTIDAE*)

GOLDEYE (*Hiodon alosoides*)

Goldeye have a disjunct distribution across Canada. There are two fairly isolated ranges, one being in the Liard River drainage of north-eastern BC (McPhail and Lindsey 1970) and the other being near the Quebec-Ontario border (Scott and Crossman 1973). The larger distribution ranges from west of the Great Lakes, to the eastern slopes of the Rocky Mountains in BC, and from Great Bear Lake in the north, south to the Mississippi River (Battle and Sprules 1960; Scott and Crossman 1973).

Goldeye are common in large muddy, clay dominated rivers (McPhail and Lindsey 1970; Brown and Coon 1994), or in small lakes, ponds and marshes (Scott and Crossman 1973). Goldeye overwinter in deeper waters of lakes and rivers (Scott and Crossman 1973). They make pre-spawning migrations upstream as observed in the Valley River, Manitoba (Gaboury 1985) and the North Saskatchewan River, near Edmonton (Paterson 1966). In the North Saskatchewan River the upstream spawning migration is followed by a further upstream migration to feed and then in the fall goldeye migrate back downstream (Paterson 1966). Goldeye were caught year round in a large deep area of the Mississippi River (Dettmers et al. 2001), possibly suggesting that no migrations occur in that population.

Goldeye begin spawning in the May (Table 7) after surface ice break-up and continue until early July (Battle and Sprules 1960; Tallman 1996). Goldeye in the Valley River, Manitoba may spawn in June (Gaboury 1985). In the North Saskatchewan River, near Edmonton, spawning does not occur until water

temperatures reach 10.0-12.2°C (Scott and Crossman 1973). Spawning takes place on shallow nearshore areas in lakes (Battle and Sprules 1960) and in pools (Tallman 1996) of turbid rivers (Scott and Crossman 1973) (Appendix 7). Spawning is thought to take place at night (Scott and Crossman 1973). Goldeye eggs are semi-buoyant (Battle and Sprules 1960) and hatch within two weeks (Scott and Crossman 1973). Growth of newly hatched goldeye is slow until July, then increases during the first summer and slows again in September. Growth rate is slower in more northern populations. Micro-crustaceans are the dominant prey of young goldeye.

Age of sexual maturity ranges between two to ten years of age depending on latitude (Battle and Sprules 1960). Northern populations, such as in Lake Claire, Alberta goldeye mature between six to nine years, while more southern populations goldeye mature between two to three years. Males mature one year earlier than females. Females may spawn every year after becoming sexually mature (Kennedy and Sprules 1967). Goldeye can live up to fourteen years and reach a maximum size of 508 mm (Scott and Crossman 1973). Goldeye feed on aquatic insects.

Table 7: Summary of stream habitat and life history characteristics of goldeye.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	S/L	S/L
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	-	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	pool	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	turbid	-	-	turbid
Oxygen Range	-	-	-	-
Optimal Temp. Range	10-12.2°C	-	-	-
Dominant Prey	-	micro-crustaceans	-	aquatic insects
Duration	May-July	-	-	-
Size Range	-	7-170 mm	-	maximum: 508 mm
Age of Maturity	-	-	2-10 years	-
Maximum Age	-	-	-	14 years

HERRINGS (*CLUPEIDAE*)

AMERICAN SHAD (*Alosa sapidissima*)

Although American shad are an Atlantic coast species found off the coast of Newfoundland and Labrador (Dempson et al. 1983), they were introduced to the Sacramento River, California in 1871 (Scott and Crossman 1973) and have since spread north to Kamchatka Peninsula in Asia, and south to Todos Santos Bay, Mexico (Page and Burr 1991). American shad were first caught in BC in 1876 and are frequently caught in the Fraser River (Clemens and Wilby 1961). Overall, American shad are not abundant in Canada (Dempson et al. 1983). Most information for this species comes from research done on Atlantic populations, which is summarized by Bradbury et al. (1999).

American shad are anadromous (Scott and Crossman 1973). Spawning only takes place in rivers or brackish water (Leim and Scott 1966; Scott and Crossman 1973; Scott and Scott 1988) (Table 8). Adults caught in Alaska range in size from 310-585 mm (fork length) (Haro et al. 1999). Movement into spawning streams begins in late April and late June (Ross et al. 1993; Quinn and Adams 1996; Bradbury et al. 1999; Olney and Hoenig 2001) when water temperatures reach at least 4°C (Leggett 1976). American shad were caught during upstream migration in an Alaska river between May and June (Haro et al. 1999). Abiotic changes in the Columbia River, caused from extensive damming of the river, have

caused an earlier migration timing (by 38 days) of American shad in the past 50 years (Quinn and Adams 1996). Spawning occurs very soon after arrival on the spawning grounds (Quinn and Adamas 1996) during May or June and into July (Leim and Scott 1966; Scott and Scott 1988) when water temperatures range between 13 - 20°C (Scott and Scott 1988). In North Carolina, spawning of American shad was recorded at temperatures up to 26.0°C (Beasley and Hightower 2000). The optimum temperature range for American shad eggs is 13.0-26.0°C, and 15.5-26.5°C for larvae (Klauda et al. 1991).

Spawning takes place in areas with moderate to strong currents (Marcy 1972; Scott and Scott 1988) where water velocity is <1.0 m/s (Ross et al. 1993), turbidity is low (2.7 NTU, Ross et al. 1993), and where the substrate is free of silt accumulation (Bradbury et al. 1999) (Appendix 8). Adults feed very little during spawning (Scott and Crossman 1973). Eggs are emitted into the water column over a mix of sand, gravel, boulder, silt and muck substrates (Leggett 1976; Morrow 1980), in water 0.2 - 12 m in depth (Bradbury et al. 1999; Ross et al. 1993), in run habitat (Ross et al. 1993). The critical factor during spawning is that the eggs need to be laid far enough upstream to allow them to drift and hatch before reaching saltwater (Bradbury et al. 1999).

American shad eggs are heavier than water, so eventually sink to the bottom during their journey downstream (Scott and Crossman 1973; Morrow 1980; Scott and Scott 1988). The eggs hatch within eight to twelve days at temperatures between 11 - 15°C (Bradbury et al. 1999). Larvae are planktonic and remain in this form for four to five weeks, before metamorphosing into the juvenile form (Bradbury et al. 1999). Juveniles continue to move downstream towards brackish water (Leim and Scott 1966), and feed mostly on copepods (Scott and Crossman 1973). Size of young fish ranges between 10-175 mm in length (Scott and Crossman 1973). Densities of post-larval American shad were higher in pool-riffle habitats than all other habitat types in the Delaware River (Ross et al. 1993). When water temperatures fall below 15°C during the fall, all juvenile American shad move into salt water (Scott and Crossman 1973; Morrow 1980). Some will remain in the estuary for another year, while others move directly to the open ocean (Bradbury et al. 1999).

Post-spawning migration back to the ocean is immediate (Leim and Scott 1966; Scott and Crossman 1973; Leggett 1976; Morrow 1980), or is delayed until October or November (Scott and Scott 1988). Atlantic populations of American shad have a distinct and extensive ocean migration pattern whereby the migration pattern is dictated by ocean water temperatures (Dempson et al. 1983; Bradbury et al. 1999). American shad preferred temperature range in the ocean is 13-18°C (Bradbury et al. 1999). Others suggest that American shad prefer ocean water temperatures between 2 - 15°C (Neves and Depres 1979). On the Atlantic coast, American shad will spend two to six years in the ocean before returning to spawn (Leggett 1976; Leggett and Carscadden 1978; Morrow 1980; Melvin et al. 1986). It is suggested that there is a latitudinal gradient in the occurrence of repeat spawning, with more northern populations spawning more times than southern populations (Leggett and Carscadden 1978). American shad in Canada may live up to 13 years, and spawn up to seven times (Bradbury et al. 1999). In a Virginia study, American shad matured between the ages of three to seven (Maki et al. 2001).

Table 8: Summary of stream habitat and life history characteristics of American shad.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S/O	O	O
Stream Gradient	-	-	-	-
Depth Range	0.2-12 m	-	-	-
Dominant Substrate	muck-gravel, boulder	-	-	-
Dominant Cover	-	pelagic	-	-
Dominant Habitat	run	pool-riffle	-	-
Velocity Range	moderate-strong, <1.1 m/s	-	-	-
Turbidity Range	low	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	13-20°C	13-26.5°C	13-18°C	13-18°C
Dominant Prey	-	copepods	copepods	plankton
Duration	May-July	-	-	upstream migration: April-June
Size Range	-	10-175 mm	-	310-585 mm
Age of Maturity	-	-	3-7 years	-
Maximum Age	-	-	-	13 years

CARPS AND MINNOWS (*CYPRINIDAE*)

CHISELMOUTH (*Acrocheilus alutaceus*)

Chiselmouth inhabit waters in BC, Oregon, Washington, Nevada and Idaho (Scott and Crossman 1973). Their distribution within BC is limited and as a result they are Blue listed (CDC 2001). In BC, chiselmouth are found in streams and rivers including Wolfe Creek, Nazko, Euchiniko, Kettle and Okanagan rivers (Cannings and Ptolemy 1998), yet there are some populations that inhabit large, relatively productive lakes in the Fraser and Columbia River drainages (Scott and Crossman 1973; Cannings and Ptolemy 1998).

Chiselmouth prefer warm areas (> 20°C) of moderate to fast current (Wydoski and Whitney 1979; Rosenfeld et al. 2000b) (Table 9; Appendix 9). Rosenfeld et al. (2000b) found that chiselmouth were never present in rivers < 17 m wide in the Blackwater River drainage, BC. In a related study, chiselmouth were found in 14 of 48 surveyed streams in the Blackwater River watershed with an average bank-full width of 39.5 m, average maximum summer temperature of 21.2°C, and an average watershed gradient of 0.9% (Porter et al. 2000). Temperature may be what determines chiselmouth distribution within drainages (Rosenfeld et al. 2000b).

Spawning takes place during late-May to July, with the peak in June (Gray and Dauble 2001). Possible upstream and downstream spawning migrations were observed in the Hanford Reach of the Columbia River during early summer and early fall respectively (Gray and Dauble 2001). Peak spawning occurs between 13-18°C, in smaller tributaries to the Columbia River (Gray and Dauble 2001). Spawning likely occurs over open bottom or boulder substrates (Scott and Crossman 1973). Eggs are laid in clumps over stones and rocks (Gray and Dauble 2001).

Young-of-the-year and juvenile chiselmouth rear in shallow (< 1 m), vegetated, slow flowing backwaters and river margins (Rosenfeld et al. 1998; Rosenfeld et al. 2000b). Often young-of-the-year and juveniles form schools with other species of cyprinids. Adult chiselmouth are found in deep (> 1 m), fast flowing water over cobble and boulder substrate, presumably because they feed on algae and diatoms that grows on the substrate. Chiselmouth have also been described to inhabit small creeks over sand and gravel substrates (Page and Blurr 1991). Rosenfeld et al. (2000b) suggested that adult chiselmouth migrate to lakes from rivers to overwinter.

Sexual maturity is probably at three to four years of age for BC populations (Cannings and Ptolemy 1998), yet chiselmouth from the Columbia were found to mature between four and five years (Gray and Dauble 2001). Maximum age is eight years in the Columbia River (Gray and Dauble 2001), and maximum size is 225 mm (Scott and Crossman 1973).

Table 9: Summary of stream habitat and life history characteristics of chiselmouth.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S > 17 m wide/L	S < 17 m wide/L
Stream Gradient	-	-	0.9%	0.9%
Depth Range	-	< 1 m	< 1 m	< 1 m
Dominant Substrate	none, boulder	-	-	cobble, boulder
Dominant Cover	-	vegetation	vegetation	-
Dominant Habitat	-	backwater, margins	backwater, margins	-
Velocity Range	-	-	-	moderate-fast
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	13-18°C	-	> 20°C	< 20°C
Dominant Prey	-	-	algae, diatoms	algae, diatoms
Duration	May-July, peak June	-	-	-
Size Range	-	-	-	maximum: 225 mm
Age of Maturity	-	-	3-5 years	-
Maximum Age	-	-	-	8 years

GOLDFISH (*Carassius auratus*)

Goldfish are native to eastern Asia and China, but have been introduced to most parts of the world (Scott and Crossman 1973). As early as 960 in the Sung Dynasty (Hervey and Hems 1968), goldfish were kept as pets. Goldfish farms were established in Maryland in the late 1800s (Scott and Crossman 1973). Since then, goldfish have established themselves throughout the United States, and occur sporadically in Canada. In 1973, Scott and Crossman reported that goldfish in BC were only known from a large pond in Salmon Arm and a small lake near Kamloops. In 1970, potential spawning locations were reported near Prince George (BC Fisheries 2002). Now, goldfish are present within the Kootenay, Osoyoos and Fraser river drainages, as well as locations on the south coast and Vancouver Island (BC Fisheries 2002). Goldfish are found in warm, muddy, turbid water of rivers, ponds and lakes most often associated with vegetation in shallow areas (Scott and Crossman 1973; Page and Burr 1991) (Table 10; Appendix 10). They feed on aquatic invertebrates and vegetation and grow to a maximum size of 280 mm (Scott and Crossman 1973).

Spawning takes place during spring between May and June in shallow weedy areas (Scott and Crossman 1973; BC Fisheries 2002). Eggs are adhesive and are laid during the day over submerged aquatic vegetation. Females often mate with more than one male during spawning. Eggs incubate for three to four days when water temperatures are between 18.5 - 29.5°C, but eggs can hatch within 64 - 72 hours if water temperatures are between 24 - 28°C (Battle 1940).

Table 10: Summary of stream habitat and life history characteristics of goldfish.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	S/L	S/L
Stream Gradient	-	-	-	-
Depth Range	shallow	-	shallow	shallow
Dominant Substrate	-	-	mud	mud
Dominant Cover	vegetation	-	vegetation	vegetation
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	turbid	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	18.5-29°C	-	-	-
Dominant Prey	-	-	-	aquatic invertebrates, vegetation
Duration	May-June	-	-	-
Size Range	-	-	-	280 mm
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	-

LAKE CHUB (*Couesius plumbeus*)

Lake chub are found throughout BC and Yukon, in the Fraser, Columbia, Liard, Skeena, Peace, Yukon and Mackenzie river drainages (McAllister 1961; Scott and Crossman 1973). However, they are not present along the coast or on coastal islands in BC (Scott and Crossman 1973). Their range extends from the Yukon River in Alaska, to the Mackenzie delta, south through Alberta, Saskatchewan, and Manitoba, to Nova Scotia (McAllister 1961; McPhail and Lindsey 1970; Scott and Crossman 1973). In the United States, scattered populations of lake chub can be found in New England, New York, Michigan, Wisconsin, Minnesota, across to Colorado and Idaho (Scott and Crossman 1973; Morrow 1980). Lake chub prefer lake habitat, but are also found in clear and murky streams and rivers (McAllister 1961; McPhail and Lindsey 1970; Scott and Crossman 1973). They have also been found at the outlet of hot springs (McPhail and Lindsey 1970).

Lake chub are bottom dwellers, and commonly inhabit shallow water in lakes (McPhail and Lindsey 1970; Emery 1973; Becker 1983), although they can be found in rivers. In the Peace River drainage in BC, lake chub have been found in streams dominated by deep pools, gravel substrates, and a high percentage of total cover (Hopcraft et al. 1995) (Table 11; Appendix 11). Deep pools, LWD, undercut banks and overstream vegetation were described as the cover types used by lake chub (Hopcraft et al. 1995). In small lakes in BC, they are always associated with the bottom regardless of depth (McPhail and Lindsey 1970). Lake chub are often found over primarily sandy bottoms that have some interspersed boulders (Becker 1983), and feed on aquatic insects (Scott and Crossman 1973), freshwater shrimp, algae and small fish (YRR 2002). They reach a maximum size of 227 mm (Scott and Crossman 1973).

There is little information available on the spawning behaviour or habitat of lake chub. Because of the wide distribution of this species, timing of spawning may vary between locations. Spawning has been recorded in mid-May in Saskatchewan, late-May early-June in BC (McPhail and Lindsey 1970), August in the NWT (Richardson 1935) and, April (Scott and Crossman 1973) and June in Ontario (Dymond 1926). Lake chub migrate from lakes into tributary streams to spawn over gravel or over and underneath large rocks in shallow water (from McPhail and Lindsey 1970; Morrow 1980). In lakes, spawning usually takes place in shallow shores over rocky substrates, but spawning over silt, leaves, gravel, cobble and boulder has been observed (Brown et al. 1970). Males do not build nests or protect eggs (Brown et al. 1970; Scott and Crossman 1973). Life expectancy of lake chub in central BC lakes is rarely beyond five years of age, with sexual maturity occurring at ages three to four (McPhail and Lindsey 1970).

Table 11: Summary of stream habitat and life history characteristics of lake chub.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S/L	S/L	S/L
Stream Gradient	-	-	-	-
Depth Range	shallow	-	-	-
Dominant Substrate	gravel, large rocks	-	-	gravel
Dominant Cover	-	-	-	LWD, undercut banks, overhanging vegetation
Dominant Habitat	-	-	-	pool
Velocity Range	-	-	-	-
Turbidity Range	-	-	--	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	-	insects, algae, freshwater shrimp, small fish
Duration	May-June	-	-	-
Size Range	-	-	-	maximum: 227 mm
Age of Maturity	-	-	3-4 years	-
Maximum Age	-	-	-	5 years

COMMON CARP (*Cyprinus carpio*)

Carp are native to temperate areas in Asia, such as China, but are now found across Europe and North America (Carl et al. 1967). Carp first appeared in BC in Okanagan Lake in 1917 (Clemens et al. 1939). They were thought to have been introduced into Washington State in 1882 (Carl et al. 1967). By 1946, carp were present to the north Thompson River at Little Fort, Kamloops and the Fraser River to Vancouver. In the early 1900s, carp were also introduced to a pond on Vancouver Island. Carp inhabit a variety of habitats, but prefer large, turbid, slow flowing water bodies (Kottelat 1997; Dettmers et al. 2001), including lakes and large rivers (Brown and Coon 1994), and utilize bottom habitat (Clemens et al. 1939) (Table 12). In the Columbia River, common carp were caught feeding along shallow river margins during the spring, and in pools near shore in the summer (Gray and Dauble 2001) (Appendix 12).

Spawning is initiated by warming water temperatures during spring and early summer (Scott and Crossman 1973). Carp move into weedy (submergent and emergent vegetation), shallow areas with mucky bottoms (Swee and McCrimmon 1966). Gray and Dauble (2001) observed common carp spawning in shallow vegetated backwaters of the Columbia River in water 13-16°C. Common carp form large spawning groups that congregate near the surface (Scott and Crossman 1973). As water temperatures reach 17°C, smaller groups of one to three females and up to 15 males form and begin to spawn (McCrimmon 1968; Scott and Crossman 1973). Spawning ceases once water temperatures reach 28°C (Swee and McCrimmon 1966; McCrimmon 1968). The adhesive eggs are emitted into the water, and settle on weeds, grasses and roots (McCrimmon 1968). Eggs will hatch within three to six days depending on water temperature (Swee and McCrimmon 1966). In Lake St. Lawrence, young-of-the-year remain within shallow regions up to two weeks after hatching (Swee and McCrimmon 1966). Young-of-the-year range in size from 10-190 mm in length (Scott and Crossman 1973). Adults stay within 3 m of water during the late summer and fall, and only move to deeper water during the winter when shallow areas freeze (Swee and McCrimmon 1966).

Males reach sexual maturity at ages three to four, and females between ages four to five (McCrimmon 1968). Individuals can reach over 20 years of age in North America (McCrimmon 1968), and over 50 pounds in weight (Scott and Crossman 1973). They feed primarily on invertebrates and plants (Scott and Crossman 1973). Upper lethal temperature limit is 31 - 34°C (Black 1953).

Table 12: Summary of stream habitat and life history characteristics of common carp.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	L/S	L/S
Stream Gradient	-	-	-	-
Depth Range	shallow	-	-	shallow
Dominant Substrate	muck	-	-	-
Dominant Cover	vegetation	-	-	-
Dominant Habitat	backwater	-	-	margin, pool
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	13-28°C	-	-	lethal: 31-34°C
Dominant Prey	-	-	-	invertebrates, plants
Duration	spring-early summer	-	-	-
Size Range	-	10-190 mm	-	>23 kg
Age of Maturity	-	-	female: 4-5 years, male: 3-4 years	-
Maximum Age	-	-	-	> 20 years

BRASSY MINNOW (*Hybognathus hankinsoni*)

Brassy minnow are common from Michigan to New York, and the St. Lawrence River (Scott and Crossman 1973). The distribution of brassy minnow within BC is fragmented. They are found in the lower Fraser River valley in areas such as the Chilliwack Gravel Slough, Sumas, Brunette, Stave, and Salmon rivers, and Hatzic, Burnaby and Deer lakes (Cannings and Ptolemy 1998). Brassy minnow also occur near Horsefly on the Caribou Plateau in Wright, Hoodoo, Dogs, Merton creeks, the Horsefly River, Shelley Slough, and Bear, Esker, Huble and Summit lakes. There are a few unconfirmed reports that brassy minnow are present in the Peace River drainage. It is believed that brassy minnow have disappeared from many locations from central BC. As a result, they are Blue listed (CDC 2001).

Brassy minnow inhabit primarily small, slow flowing weedy creeks, cool, acidic, boggy streams and small, shallow lakes (Dymond 1939; McPhail and Lindsey 1970; Cannings and Ptolemy 1998) (Table 13). Often they are present over sand, gravel or mud with organic material present (Cannings and Ptolemy 1998) (Appendix 13).

Spawning takes place during May or June (Scott and Crossman 1973). Brassy minnow spawn during the spring in shallow areas depositing their eggs near or on vegetation (Dobie et al. 1956; Becker 1983). Spawning has been recorded over silt substrate (Scott and Crossman 1973). Spawning is usually initiated when water temperatures reach between 10 - 12.8°C (Dobie et al. 1956). Sexual maturity is at one to two years of age (Dobie et al. 1956), and adults are on average 100 mm in length (Scott and Crossman 1973).

Table 13: Summary of stream habitat and life history characteristics of brassy minnow.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	S/L	S/L
Stream Gradient	-	-	-	-
Depth Range	shallow	-	-	-
Dominant Substrate	silt	-	-	organic-gravel
Dominant Cover	vegetation	-	-	-
Dominant Habitat	-	-	-	off-channel
Velocity Range	-	-	-	slow
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	10-12.8°C	-	-	-
Dominant Prey	-	-	algae, phytoplankton	algae, phytoplankton
Duration	May-June	-	-	-
Size Range	-	-	-	100 mm
Age of Maturity	-	-	1-2 years	-
Maximum Age	-	-	-	-

PEARL DACE (*Margariscus margaritai*)

Pearl dace distribution ranges from the St. Lawrence River and Nova Scotia to the eastern border of BC and south of the Sass River in the NWT (Scott and Crossman 1973). In BC, pearl dace are Blue listed (CDC 2001). They are only found in two or three locations. They inhabit Lattice Creek, a tributary of the Redwillow River in the Kiskatinaw Plateau of north-eastern BC (Cannings and Ptolemy 1998; Haas 1998), and Tsinhia Lake (Cannings and Ptolemy 1998). They once inhabited Charlie Lake, BC (Cannings 1993), but may have been eliminated from this lake due to the introduction of piscivorous fish (Cannings and Ptolemy 1998), although Haas (1998) does not report this extirpation. Pearl dace are thought to hybridize with lake chub, northern redbelly dace and finescale dace (Wells 1981; Nelson and Paetz 1992; McPhail and Carveth 1993b). It has been suggested that there may not be any "pure" populations of pearl dace in BC (McPhail and Carveth 1993b). The designation of a subspecies, the northern pearl dace (*Semotilus margarita nachtriebi*) that is unique to Canada inhabiting waters from the Maritimes to BC, has been proposed (Scott and Crossman 1973).

Depending on the general location, pearl dace prefer different types of habitats (Table 14). In BC, pearl dace are more common in slow flowing, tea coloured creeks (Cannings and Ptolemy 1998). In northern locations, pearl dace are found in bog drainage systems, small lakes and ponds (Bendell and McNicol 1987), while in more southern locations, they are found in clean, cool headwater streams (McPhail and Lindsey 1970; Scott and Crossman 1973). Elsewhere they are found in peaty waters and beaver ponds (Scott and Crossman 1973). In Ontario, pearl dace inhabit deep waters of small lakes (Tallman et al 1984; Bendell and McNicol 1987). Pearl dace feed on invertebrates, plankton and filamentous algae (Scott and Crossman 1973; Tallman and Gee 1982).

Pearl dace spawn in tributary streams or in vegetation along the edges of lakes during spring just after ice-melt (Tallman et al. 1984). The ideal spawning temperature range is 17.2-18.3°C (Scott and Crossman 1973). In beaver ponds and small lakes, spawning is over organic material (Bendell and McNicol 1987). In streams, pearl dace spawn in water around 0.6 m deep over sand or gravel (McPhail and Lindsey 1970), or hard substrates (Langlois 1929) (Appendix 14). Males do not build nests, but defend small territories around the spawning sites (Langlois 1929). Young-of-the-year are approximately 55-65 mm in length (Scott and Crossman 1973). Sexual maturity is at age two (Becker 1983). Females may live to four years of age, while males only reach three years (Nelson and Paetz 1992). Adult pearl dace reach a maximum size of 158 mm (Scott and Crossman 1973).

Table 14: Summary of stream habitat and life history characteristics of pearl dace.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	S/L	S/L
Stream Gradient	-	-	-	-
Depth Range	<0.6 m	-	-	-
Dominant Substrate	gravel, sand, hard	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	slow	slow
Turbidity Range	-	-	-	tea coloured
Oxygen Range	-	-	-	-
Optimal Temp. Range	17.2-18.3°C	-	-	-
Dominant Prey	-	-	algae, invertebrates, plankton	algae, invertebrates, plankton
Duration	spring	-	-	-
Size Range	-	55-65 mm	-	maximum: 158 mm
Age of Maturity	-	-	2 years	-
Maximum Age	-	-	-	female: 4 years, male: 3 years

PEAMOUTH CHUB (*Mylocheilus caurinus*)

Peamouth chub are found in lakes and rivers of BC from the Peace, Nass, Skeena, Fraser and Columbia rivers (Scott and Crossman 1973). They are found in a few lakes on the west coast and southern portion of Vancouver Island, and other small Gulf Islands (Scott and Crossman 1973). Peamouth chub are one of the only cyprinids that are able to withstand saline water, and have been documented in brackish water off Spanish Banks (Scott and Crossman 1973).

Peamouth chub are bottom feeders (Scott and Crossman 1973). Typically, peamouth chub form small schools and inhabit shallow, vegetated waters of lakes and rivers (Clemens et al. 1939; Ricker 1952; Godfrey 1955; Narver 1967; Scott and Crossman 1973; Beauchamp et al. 1995; Porter and Rosenfeld 1999). Porter et al. (2000) conducted fish and fish habitat surveys in 48 streams in the Blackwater River watershed during the summers of 1996 and 1997. Peamouth chub were found in 13 of 48 streams with an average bank-full width 33.9 m, average maximum summer temperature of 21.3°C, and an average watershed gradient of 1.0% (Table 15).

Spawning in BC has been recorded in May or June (Brett and Pritchard 1946a, Carl et al. 1967). Peamouth chub spawn in groups, usually consisting of several males and one female, although these groups can include up to several hundred individuals (Schultz 1935). Spawning takes place over stony, rubble substrate in shallow nearshore areas of lakes, when water temperatures reach 12°C (Schultz 1935) (Appendix 15). In the Columbia River, spawning commenced at 10-11°C, and peaked at 12-15°C (Gray and Dauble 2001). The adhesive eggs are emitted into the water and adhere to the coarse substrate (Schultz 1935). In lakes, young-of-the-year peamouth chub remain in shallow nearshore areas until the end of their first summer, when they move into deeper water (Carl et al. 1967). In the Nazko River, BC, juvenile peamouth chub prefer slow flowing backwaters, 0.25 - 0.5 m deep, near gravel substrate and vegetation, in water < 0.1 m/s (Porter and Rosenfeld 1999). In the Columbia River, juvenile peamouth chub were caught in the shallow nearshore area in schools with other cyprinids and catostomids (Gray and Dauble 2001).

Upper lethal temperature was recorded to be 27°C by Black (1953). Peamouth chub can live up to seven years of age (Clemens 1939), and reach a maximum length of 318 mm (Scott and Crossman 1973). They feed mostly on insects (Scott and Crossman 1973).

Table 15: Summary of stream habitat and life history characteristics of peamouth chub.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	S/L	S/L
Stream Gradient	-	-	1%	1%
Depth Range	-	-	0.25-0.5 m	shallow
Dominant Substrate	coarse	-	gravel	-
Dominant Cover	-	-	vegetation	-
Dominant Habitat	-	-	backwater, nearshore	-
Velocity Range	-	-	<0.1 m/s	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	10-15°C	-	21.3°C	lethal: 27°c
Dominant Prey	-	-	insects	insects
Duration	May-June	-	-	-
Size Range	-	-	-	maximum: 318 mm
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	7 years

EMERALD SHINER (*Notropis atherindoides*)

Emerald shiners are widespread from tributaries in the southern parts of the Mackenzie River, to the St. Lawrence River and the Great Lakes, south to the Mississippi Valley, Gulf coast in Alabama and the Trinity River, Texas (Scott and Crossman 1973). In BC, emerald shiners are Red listed (CDC 2001), as they have only been found at one site but may be more widespread in the Liard and Nelson river drainages (Cannings and Ptolemy 1998). This site is in a section of the Fort Nelson River at Old Fort Nelson, where the river is 2 - 10 m wide, muddy bottomed, with tea coloured water (Cannings and Ptolemy 1998) (Table 16; Appendix 16). .

Emerald shiners are found in large, open lakes and rivers (Scott and Crossman 1973), or at the mouths of smaller streams (Cannings and Ptolemy 1998). There is virtually no information available that pertains to their riverine habitat associations as they primarily inhabit lakes (Scott and Crossman 1973). They are found in large schools in the limnetic zone (Fuchs 1967; Scott and Crossman 1973). During the summer and winter these schools stay in offshore areas, during the fall they move inshore often under piers, docks and near river mouths, and during the spring they inhabit surface waters during the day and deep water at night (Scott and Crossman 1973).

Emerald shiners spawn in late spring and summer (Scott and Crossman 1973), from July to late-August (Dymond 1926; Fish 1932; Langlois 1954). They are thought to spawn in midwater (Scott and Crossman 1973), offshore at depths of 2 - 6 m over clean substrate (Becker 1983). Eggs fall to the bottom and hatch within 32 hours, at 24°C (Flitner 1964; Scott and Crossman 1973). Young-of-the-year form large schools that congregate in nearshore areas (Fuchs 1967; Scott and Crossman 1973). Growth is very high during their first growing season (Fuchs 1967). In the fall, the young-of-the-year can be found in highest numbers over sandy beaches or in sheltered bays (Fuchs 1967). Emerald shiners do not seem to live past three years of age (McCrimmon 1956; Fuchs 1967), and reach a maximum size of 102 mm in length (Scott and Crossman 1973).

Table 16: Summary of stream habitat and life history characteristics of emerald shiner.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L	L	L	L/S 2-10 m wide
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	-	-	-	mud
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	tea coloured
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	rotifers	rotifers, insects
Duration	-	-	-	-
Size Range	-	-	-	maximum: 102 mm
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	3 years

SPOTTAIL SHINER (*Notropis hudsonius*)

Spottail shiners occur across North America, from the Mackenzie River to the St. Lawrence River in Quebec, south to Georgia, Iowa and Missouri (Scott and Crossman 1973). Spottail shiners are present only in the far north-eastern corner of BC, primarily in Maxhamish Lake (Cannings and Ptolemy 1998). They were introduced to Charlie Lake in 1986 and have been collected in the Beatton River since 1983 and the Peace River since 1989 (BC Fisheries 2002). Because of their limited distribution in BC, spottail shiners are Red listed (CDC 2001).

Spottail shiners are most commonly found in large lakes and some have been recorded in large turbid rivers (McPhail and Lindsey 1970) (Table 17). Only spawning habitat in rivers has been recorded for spottail shiners. They are often the most abundant minnow caught in northern lakes. In lakes, spottail shiners are found in shallow areas with moderate amounts of vegetation over sand and rocks (McCann 1959; Bryan et al. 1992; Cannings and Ptolemy 1998). In Maxhamish Lake, BC, spottail shiners are found along the south shore and near the mouth of an inlet stream (Cannings and Ptolemy 1998).

Spawning takes place during spring and early summer depending on latitude and temperature (Scott and Crossman 1973; Becker 1983). More northern populations spawn later in the year (July), while in southern lakes, spawning takes place during May (McCann 1959; Smith and Kramer 1964; Peer 1966). Spawning occurs over sandy shoals in June and July in Canada (Peer 1966; Scott and Crossman 1973), or over gravel in riffles at stream mouths (Becker 1983) (Appendix 17). Adults leave the shoals after spawning and move into deeper water (Peer 1966). Eggs hatch within about a month, and young-of-the-year may remain on the shoals (Peer 1966). Smith and Kramer (1964) collected young-of-the-year and juvenile spottail shiners on the bottom and within the water column in < 7 m of water. Young-of-the-year spottail shiners rear along the shoreline and move offshore as juveniles (Bryan et al. 1992). Sexually maturity is after one to four years, once a minimum total length of 68-72 mm is reached (Peer 1966; McPhail and Lindsey 1970). Total life span is between four to five years (McCann 1959; Smith and Kramer 1964), and maximum size is 132 mm (Scott and Crossman 1973).

Table 17: Summary of stream habitat and life history characteristics of spottail shiner.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L/S	L	L	L/S large rivers
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	gravel	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	riffle	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	turbid
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	larval insects, algae	larval insects, algae
Duration	May-July	-	-	-
Size Range	-	-	68-72 mm at sexual maturity	maximum 132 mm
Age of Maturity	-	-	1-4 years	-
Maximum Age	-	-	-	4-5 years

NORTHERN REDBELLY DACE (*Phoxinus eos*)

The range of northern redbelly dace extends from the Peace River, Alberta to Nova Scotia, south to New York and north to Fuller Lake, NWT (McPhail and Lindsey 1970). They are only found in the northeast edge of BC and were reported in Charlie Lake by McPhail and Lindsey (1970). The BC location signifies the most westerly point where northern redbelly dace occur. Redbelly dace hybridize with finescale dace (Hubbs and Brown 1929; New 1962; Legendre 1969; Das and Nelson 1989), and hybrid populations are known to exist in Graveyard Creek and Tsinhis Lake, BC (Cannings and Ptolemy 1998). It was suggested that no "pure" populations of northern redbelly dace exist in BC (McPhail and Carveth 1993b). There is also documented evidence of morphological variation among populations in three different Ontario watersheds (Toline and Baker 1993).

Normally northern redbelly dace are found in quiet, warm waters of boggy ponds, small lakes and pools, and within creeks that have primarily silt and detritus bottoms (Scott and Crossman 1973) (Table 18; Appendix 18). Often water in these types of habitats is dark and slightly acidic. Northern redbelly dace feed on filamentous algae and other vegetation (McPhail and Lindsey 1970).

Northern redbelly dace spawn in spring and early summer, depending on latitude, with more northern populations usually spawning later (Scott and Crossman 1973). In Alberta, northern redbelly dace spawn in mid-June and late July when temperatures range between 13 - 18°C (Das and Nelson 1990). Some females in more southern populations will spawn more than once during a season thereby extending the spawning season to late August (Hubbs and Cooper 1936; Powles et al. 1992). Cooper (1935) observed spawning activity in May and August in Michigan, while McPhail and Lindsey (1970) reported spawning in late August in northern Alberta. Females deposit non-adhesive eggs over and within filamentous algae with one or more males (Cooper 1935; Hubbs and Cooper 1936). Eggs hatch within eight to ten days (Cooper 1935) at temperatures between 21 - 26.7°C (Hubbs and Cooper 1936).

Sexual maturity depends on the time of hatch. Individuals hatched in early summer spawn the next summer, but individuals hatched during late summer spawn after two summers (Hubbs and Cooper 1936). The oldest male was recorded to be six years of age, and the oldest female was eight years of age (Scott and Crossman 1973). Average life span is around three years (Cooper 1935).

Table 18: Summary of stream habitat and life history characteristics of northern redbelly dace.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L	L	L	L/S
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	-	-	-	silt
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	stained
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	-	algae and vegetation
Duration	May-September	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	1-2 years	-
Maximum Age	-	-	-	8 years

FINESCALE DACE (*Phoxinus neogaeus*)

Finescale dace distribution is split into western and eastern ranges. In the west they are found from the Mackenzie River drainage south through Alberta, into BC and Colorado (Scott and Crossman 1973). On the east coast, finescale dace inhabit waters from New Brunswick into the Great Lakes and westward to the western edge of Ontario (Scott and Crossman 1973). In BC, this species is only found in the Fort Nelson River and One Island Lake (Scott and Crossman 1973). Typically finescale dace inhabit boggy ponds, lakes and pools in streams over silt and near vegetation (Scott and Crossman 1973; Page and Burr 1991) (Table 19; Appendix 19). This species hybridizes with northern redbelly dace (Hubbs and Brown 1929; New 1962; Legendre 1969; Das and Nelson 1989), and hybrid populations are known to exist in Graveyard Creek and Tsinhis Lake, BC (Cannings and Ptolemy 1998).

Spawning in Wisconsin was observed during April to June (Becker 1983). In an Alberta lake, finescale dace spawn in mid-June and late July when temperatures ranged between 13 - 18°C (Das and Nelson 1990).

Table 19: Summary of stream habitat and life history characteristics of finescale dace.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L	L	L	L/S
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	-	-	-	silt
Dominant Cover	-	-	-	vegetation
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	stained
Oxygen Range	-	-	-	-
Optimal Temp. Range	13-18°C	-	-	-
Dominant Prey	-	-	-	-
Duration	April-July	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	-

FATHEAD MINNOW (*Pimephales promelas*)

The native range of fathead minnow is from the southern drainages of Great Slave Lake, NWT, south to Mexico, and east to New Brunswick (McPhail and Lindsey 1970). Their native range includes the Peace River, but does not extend into BC. Because of their introduction into the province, fathead minnow are present on the BC portion of the Peace River, on Vancouver Island, and the lower mainland, including the lower Fraser River (Gordan Haas, University of Alaska Museum, 245 O'Neill Building, Fairbanks, AK, USA 99775-7220, personal communication). Typically, fathead minnow prefer still, muddy waters in ponds and small lakes (Bendell and McNicol 1987) (Table 20; Appendix 20). They are also found in muddy rivers and ditches (McPhail and Lindsey 1970; Scott and Crossman 1973), clear, acidic beaver ponds (Dymond 1926; Dymond and Scott 1941), and saline lakes (Rawson and Moore 1944; Nelson 1968a), where they feed on insects (Scott and Crossman 1973). The fathead minnow is thought to be adaptable to quickly changing environmental conditions, but has limited competitive abilities (Cross 1967).

Spawning habitat has been described from lakes. Spawning activities start when water temperatures reach 15.6°C or 17.8°C (Dobie et al. 1956; Scott and Crossman 1973) during May to August (Dymond 1926; Markus 1934; Richardson 1937; Toner 1943; Scott and Crossman 1973). Nests are selected under rocks, lily pads, branches or logs in water < 1 m deep by males (Wynne-Edwards 1932; Markus 1934; Richardson 1937). Males attract females to the nest (Richardson 1937) where the females deposit the adhesive eggs under the surface of the log or rock (Wynne-Edwards 1932; Markus 1934). Males fertilize the eggs and the females are driven away from the nest (Richardson 1937). Males will mate with more than one female, and females will deposit eggs in more than one nest in a single breeding season (Wynne-Edwards 1932). Eggs hatch within five days at 25°C (Scott and Crossman 1973). Sexual maturity is generally not until two years, but individuals in southern areas have been observed spawning within their first year of life (Markus 1934). Individuals often do not live past two years of age, and die after spawning (Markus 1934), although this has not been studied for Canadian populations. It is thought, due to colder water temperature in Canada, fathead minnow may live up to three years (Scott and Crossman 1973).

Table 20: Summary of stream habitat and life history characteristics of fathead minnow.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L	L	L	L,S
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	-	-	-	mud
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	slow
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	15.6-17.8°C	-	-	-
Dominant Prey	-	-	-	insects
Duration	May-August	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	1-2 years	-
Maximum Age	-	-	-	2-3 years

FLATHEAD CHUB (*Platygobio gracilis*)

Flathead chub are found from the Mackenzie River in the NWT to Lake Winnipeg in Manitoba, south to the Mississippi and Rio Grande rivers (McAllister 1961; Scott and Crossman 1973). In BC, flathead chub

occur in the Peace River system. Carl et al. (1967) reported samples from Lynx Creek east of Hudson Hope, and the Fort Nelson and Muskwa rivers. Flathead chub inhabit muddy, turbid, flowing main channel rivers (McAllister 1961; Olund and Cross 1961), but move into smaller streams to spawn (Olund and Cross 1961; Scott and Crossman 1973) (Table 21; Appendix 21). They are seldom found in lakes or ponds (Olund and Cross 1961; Scott and Crossman 1973).

Spawning takes place in summer, when water levels are at their lowest (Olund and Cross 1961). Ripe flathead chub have been collected in August in the Milk River, June in the Saskatchewan River, and June in the Red Deer River (Olund and Cross 1961). Spent individuals have been captured in the Mackenzie River in June, and August in the Peace River (McPhail and Lindsey 1970). Sexual maturity is attained at a size of 85 mm (Olund and Cross 1961) or by age five for females (Tripp et al. 1981 from Tallman 1996). Mature individuals range in size from 198-314 mm (Tallman 1996). Flathead chub feed on invertebrates (Scott and Crossman 1973).

Table 21: Summary of stream habitat and life history characteristics of flathead chub.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S	S
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	-	-	-	mud
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	main channel
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	turbid
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	invertebrates	invertebrates
Duration	June-August	-	-	-
Size Range	-	-	-	198-314 mm
Age of Maturity	-	-	85 mm, female: 5 years	-
Maximum Age	-	-	-	-

NORTHERN PIKEMINNOW (*Ptychocheilus oregonensis*)

Northern pikeminnow inhabit waters of the Fraser, Columbia and Skeena river drainages in Canada and the United States (Scott and Crossman 1973). Apart from Summit and McLeod lakes in the Peace River drainage, and the stretch of the Peace River to the townsite of Peace River in Alberta, northern pikeminnow are found west of the Continental Divide (Scott and Crossman 1973).

Northern pikeminnow are bottom feeders and piscivores (Table 22), often found in the nearshore area of lakes (Clemens et al. 1939; Ricker 1952; Godfrey 1955; Beauchamp et al. 1995; Collis et al. 1995), and large rivers (Buchanan et al. 1981). Porter et al. (2000) conducted fish and fish habitat surveys in 48 streams in the Blackwater River watershed during the summers of 1996 and 1997. Northern pikeminnow were found in 19 of 48 streams with an average bank-full width of 34.0 m, average maximum summer temperature of 21.4°C, and an average watershed gradient of 0.9%.

Northern pikeminnow are thought to be a major predator and source of mortality on juvenile salmon in rivers (Buchanan et al. 1981; Zimmerman 1999) and lakes (Rieman and Beamesderfer 1990; Tabor et al. 1993; Beauchamp et al. 1995; Collis et al. 1995; Friesen and Ward 1999). In the early 1990's the Northern Pikeminnow Management Program was established in the lower Columbia River to reduce northern pikeminnow abundance so to reduce predation rate on juvenile salmonids (Rieman and Beamesderfer 1990; Beamesderfer et al. 1996; Zimmerman and Ward 1999).

Adult northern pikeminnow migrate upstream to spawn in tributary streams and mainstem rivers (Martinelli and Shively 1997). Spawning also occurs in lakes along shallow shorelines, and near the mouth of tributary streams, but will occur in tributary streams when suitable habitat is not available within the lake (Jeppson and Platts 1959; Patten and Rodman 1969). In lakes and rivers, spawning takes place during May to July over gravel substrate (Jeppson and Platts 1959; Carl et al. 1967; Patten and Rodman 1969; Scott and Crossman 1973), at temperatures between 12 - 18°C (Jeppson and Platts 1959; Beamesderfer 1992). Northern pikeminnow in the Columbia River were observed spawning until August at temperatures between 14-18.5°C (Gray and Dauble 2001). In St. Joe River, Idaho, spawning takes place in areas dominated by gravel and cobble substrates, in 4.9 m of water, with bottom velocities of ≤ 0.4 m/s (Beamesderfer 1992) (Appendix 22). In the Columbia River, spawning occurs at temperatures > 14°C (June-early July), over gravel, rubble and boulder substrates in moderate water velocities (0.2-0.4 m/s) (Gadomski et al. 2001). Pre-spawning aggregated of a few hundred to a few thousand can form, but during spawning small groups of one female and several males form (Scott and Crossman 1973; Beamesderfer 1992). The sperm and adhesive eggs are broadcast into the water and settle on the substrate (Jeppson and Platts 1959; Patten and Rodman 1969; Scott and Crossman 1973; Beamesderfer 1992). Eggs hatch in approximately seven to eight days in lakes (Jeppson and Platts 1959), and in the Columbia River between eight to ten days at 15-17°C (Gadomski et al. 2001).

Larval northern pikeminnow emerge after approximately 11 days (Gadomski et al. 2001). In the lower Columbia River, larvae enter the drift between June and mid-August and in the John Day River between May and June. Abundance of larvae is low in large backwaters. Larvae will drift during the night from 1-3 days before settling along the shoreline to rear. Young-of-the-year use shallow (< 0.25 m), low-velocity, sandy and fine bottomed areas within the mainstem or backwaters of large rivers (Beamesderfer 1992; Barfoot et al. 1999; Gadomski et al. 2001). Very few larvae were caught in sled tows above cobble substrate within no or trace amounts of vegetation (Gadomski et al. 2001). Young-of-the-year feed on insects (Scott and Crossman 1973). Juveniles are found over gravel and sand substrates (Beamesderfer 1992), in shallow areas in the mainstem Columbia River (Gadomski et al. 2001). In lakes, young-of-the-year and juvenile northern pikeminnow inhabit nearshore waters in summer (Jeppson and Platts 1959), moving to deeper offshore waters in the fall (Ricker 1952,Godfrey 1955; Narver 1967; Scott and Crossman 1973). Adults tend to remain in deeper waters year round (Scott and Crossman 1973).

Sexual maturity is attained at a length of 30 cm at around age six (Scott and Crossman 1973). In the Columbia River, females mature by age five to six at 32 cm length, and males between age four and five at 25 cm length (Gray and Dauble 2001). Life expectancy of northern pikeminnow is between 15 - 20 years (McPhail and Lindsey 1970). Maximum size was recorded at 635 mm (Scott and Crossman 1973). Upper lethal temperature limit is 29°C (Black 1953).

Table 22: Summary of stream habitat and life history characteristics of northern pikeminnow.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	S/L	S/L
Stream Gradient	-	-	0.9%	0.9%
Depth Range	<4.9 m	<1.0 m	shallow	shallow-deep
Dominant Substrate	gravel-boulder	silt-gravel	sand, gravel	-
Dominant Cover	-	vegetation, pelagic	vegetation-	-
Dominant Habitat	run	backwater, margin	backwater, margins	-
Velocity Range	<0.4 m/s	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	12-18.5°C	-	-	21.4-29°C
Dominant Prey	-	insects	insects, fish	fish
Duration	May-August	-	-	-
Size Range	-	-	-	maximum: 635 mm
Age of Maturity	-	-	female: 5-6 years, male: 4-5 years	-
Maximum Age	-	-	-	20 years

LONGNOSE DACE (*Rhinichthys cataractae*)

Longnose dace occur in fast flowing streams and sometimes lakes, across North America, from the Mackenzie River drainage, south into BC, Alberta, down to Virginia, east to the Mississippi River drainage, Great Lakes, northern Manitoba, the upper St. Lawrence River, Ungava River drainages and Labrador (Scott and Crossman 1973). In BC, longnose dace are found throughout the Fraser, Columbia, Skeena and Peace river drainages. They are absent from coastal islands, the northwest corner of BC.

Longnose dace inhabit clean, swift flowing, sometimes turbulent, streams usually in riffles over substrate from gravel to boulders (Gee and Machniak 1972; Scott and Crossman 1973; McPhail and Carveth 1993b) (Table 23; Appendix 23). Porter et al. (2000) conducted fish and fish habitat surveys in 48 streams in the Blackwater River watershed during the summers of 1996 and 1997. Longnose dace were found in 19 of 48 streams with an average bank-full width 24.2 m, average maximum summer temperature of 20.5°C, and an average watershed gradient of 1.0%. Apart from a population in Okanagan Lake (Gordan Haas, University of Alaska Museum, 245 O'Neill Building, Fairbanks, AK, USA 99775-7220, personal communication), they are a benthic species (Clemens et al. 1939; Scott and Crossman 1973).

Spawning occurs during June and early-July (McPhail and Lindsey 1970; Gee and Machniak 1972; Brazo et al. 1978; Gray and Dauble 2001). Over the majority of their range, male longnose dace build and defend redds built in gravel of riffles (Bartnik 1970; Brown et al. 1970; Scott and Crossman 1973; McPhail and Carveth 1993b). Longnose dace also exhibit extensive coloration and courtship behaviours during spawning which occurs during the day (Bartnik 1970; McPhail and Carveth 1993b). However, in southern BC populations, spawning occurs at night, and no redd is built, or defended, and there is no ritualized courting behaviour or coloration (Bartnik 1972). Demersal, adhesive eggs are deposited among the substrate and defended by at least one parent (Bartnik 1970; 1972; McPhail and Lindsey 1970). Spawning can also occur in lakes on wave-swept shores (Brazo et al. 1978), or over boulder, cobble, and rubble substrates in shallow offshore areas (Gee and Machniak 1972).

In the lower Fraser River, young-of-the-year were caught in relatively swift flowing water (Gee and Northcote 1963). In lakes, young-of-the-year longnose dace are limnetic, and inhabit shallow, still nearshore waters for the first four months (McPhail and Lindsey 1970; Gee and Machniak 1972; Scott and Crossman 1973). They are often associated with cover structures such as overhanging vegetation (Gee and Machniak 1972) and sand to gravel and cobble substrates (Brazo et al. 1978). They feed

primarily on algae and plankton, and sometimes fish (Brazo et al. 1978; Edwards et al. 1983). Once at a size of 30 mm total length, young-of-the-year longnose dace move to deeper waters that have swift currents (Gee and Machniak 1972).

In the Nazko River drainage, juvenile longnose dace preferred slow flowing water in riffles, glides and backwaters, in water < 0.5 m deep, over gravel substrate (Porter and Rosenfeld 1999). Gee and Northcote (1963), collected juveniles in primarily slow flowing water (< 0.5 m/s) on the shallow banks (< 0.3 m) of the lower Fraser River. Adult longnose dace can be found in fast flowing (> 0.5 m/s), shallow (< 0.25 m) water in riffles, within boulder substrate (Gee and Northcote 1963; Porter and Rosenfeld 1999). Adults are thought to use the crevices of large substrate as refuge (McPhail and Lindsey 1970; Scott and Crossman 1973; Mullen and Burton 1995). Adult longnose dace also prefer areas with aquatic vegetation and overhead cover (Hubert and Rahel 1989). In lakes, adults are found over gravel and boulder substrates during the summer (Brazo et al. 1978), but will move into deeper, cooler waters when temperatures increase (Scott and Crossman 1973). Adults feed on insects (Scott and Crossman 1973).

Sexual maturity is at age two, and males may mature earlier than females (Bartnik 1970; McPhail and Lindsey 1970; Gibbons and Gee 1972; Brazo et al. 1978; Becker 1983). Longnose dace do not usually live past the age of four (Brazo et al. 1978), but a five year old individual was caught in the eastern United States (Reed and Moulton 1973). Maximum size is 125 mm in length (Scott and Crossman 1973).

Table 23: Summary of stream habitat and life history characteristics of longnose dace.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	S/L	S 20.4 m wide/L
Stream Gradient	-	-	1%	1%
Depth Range	-	<50 cm	<1 m	<1 m
Dominant Substrate	gravel-cobble	-	gravel-boulder	gravel-boulder
Dominant Cover	-	-	-	aquatic vegetation, crevices, overhead
Dominant Habitat	riffle	-	riffle, pool	riffle
Velocity Range	-	-	<0.5 m/s	>0.5 m/s
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	20.5°C
Dominant Prey	-	-	-	insects
Duration	June-July	-	-	-
Size Range	-	48 mm	-	maximum: 125 mm
Age of Maturity	-	-	2	-
Maximum Age	-	-	-	5

Nooksack dace (*Rhinichthys sp.*)

It is not certain if the Nooksack dace is a true species distinct from the longnose dace, or simply an isolated subspecies, as it does not occur with longnose dace (Cannings and Ptolemy 1998). There are genetic and morphological differences between Nooksack dace and longnose dace (McPhail 1993b, McPhail and Carveth 1993b), however further investigation is needed. The Nooksack dace has a very restricted range compared to the longnose dace. Nooksack dace are found in the Nooksack River to the Puyallup River systems along the east side of Puget Sound, and the Chehalis River on the outer coast of the Olympic Peninsula (McPhail and Lindsey 1986). In BC, Nooksack dace are found in small, lowland tributaries of the Nooksack River that flow primarily through urban and agricultural areas (Cannings and Ptolemy 1998; Pearson 1998), which include Bertrand, Cave, Fishtrap, and Pepin creeks (Inglis et al. 1992). These BC populations are isolated from United States populations by severely degraded habitat which Nooksack dace can not inhabit (Pearson 1998). This isolation makes the BC populations vulnerable to population decline and extirpation from anthropogenic disturbances. The population from Fishtrap Creek is in poor condition due to dredging (Inglis 1995; Cannings and Ptolemy 1998; Pearson

1998). In BC, Nooksack dace are Red listed (CDC 2001). Nooksack dace are often found in sympatry with cutthroat trout, coho salmon, steelhead, Salish sucker, and stickleback, and are a common prey item of cutthroat trout (Inglis et al. 1994).

In BC, Nooksack dace spawn at night during the spring, between April and May (McPhail 1993b) (Table 24). Eggs are deposited over gravel at the upstream end of riffles (McPhail 1993b) (Appendix 24). Young-of-the-year often form schools and reside in waters 10 - 20 cm deep in slow glides and the downstream end of pools over sand and mud (McPhail 1993b; 1997b; Inglis et al. 1994). Often by the end of their first summer and as late as September, the schools break up (Pearson 1998). Juvenile and adult Nooksack dace associate with overhead vegetation in riffles, over gravel and cobble substrates (McPhail 1993b, Inglis et al. 1994). Nooksack dace feed at night (Pearson 1998). Sexual maturity is after one year (second summer), but they do not mate until the next spring, at age two (McPhail 1993b). Usually there are four age classes present within a population (Inglis et al. 1994), however an individual six years of age has been observed (McPhail 1997b).

Table 24: Summary of stream habitat and life history characteristics of Nooksack dace.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S	S
Stream Gradient	-	-	-	-
Depth Range	-	0.1 m	-	-
Dominant Substrate	gravel	sand, mud	gravel-cobble	gravel-cobble
Dominant Cover	-	-	overhead	overhead
Dominant Habitat	upstream of riffles	glide, pool	riffle	riffle
Velocity Range	-	slow	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	-	-
Duration	April-May	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	1 year	-
Maximum Age	-	-	-	6 years

LEOPARD DACE (*Rhinichthys falcatus*)

Leopard dace are only found in the Fraser and Columbia rivers east of the Cascade Mountains (Scott and Crossman 1973), in BC, Washington, Oregon and Idaho states (Haas 1998). They are known to occur in small lakes and rivers in the Fraser River as well as the Okanagan and Lower Arrow lakes, and Pend d'Oreille and Similkameen rivers (Scott and Crossman 1973; Peden 1991). Their distribution throughout the range is spotty (McPhail and Lindsey 1993a; 1993b), particularly in the lower Fraser River where the population is thought to be disjunct from the rest of the range (Haas 1998). A very small number of leopard dace have been caught in Okanagan Lake and River and the Kootenay River (Peden 1991). Within the Canadian portion of the Similkameen River, only small juveniles are usually found (Peden and Hughes 1988). Porter et al. (2000) conducted fish and fish habitat surveys in 48 streams in the Blackwater River watershed during the summers of 1996 and 1997. Juvenile leopard dace were found in 14 of 48 streams with an average bank-full width 38.3 m, average maximum summer temperature of 21.2°C, and an average watershed gradient of 1.0% (Table 25). Adults have been captured in areas within Washington State (Peden and Hughes 1988; Peden 1991).

Spawning occurs in early July (Gee and Northcote 1963). Young-of-the-year range in size from 9-36 mm in length and feed on diptera larvae (Scott and Crossman 1973). Juvenile leopard dace studied in the Nazko River drainage, BC, were found most often in shallow, slow-flowing areas associated with fine substrate, and aquatic vegetation (Porter and Rosenfeld 1999) (Appendix 25). Adult leopard dace were

found in similar habitat as juveniles, but over a mixture of gravel, cobble and fine substrate and slightly faster flowing water (Porter and Rosenfeld 1999). Gee and Northcote (1963) collected young-of-the-year, juvenile and adult leopard dace in the lower Fraser River. All leopard dace were captured in shallow (< 1 m), slow flowing water (< 0.5 m/s). Gray and Dauble (2001) caught leopard dace in similar habitat (< 1 m), over cobble substrate, but in fast flowing water in the Columbia River. Juvenile and adult leopard dace feed on insects (Scott and Crossman 1973).

In lakes, leopard dace inhabit stone, boulder and rubble dominated low gradient beaches that have extensive reed beds offshore (Peden 1991). Juvenile leopard dace have also been found in silty, turbid wave-swept beaches of Arrow Lake (Peden 1991). Hydroelectric development and habitat loss from lake shore development (removing boulders and rocks to create a sandy beach) are thought to be possible causes for the spotty distribution of this species (Peden 1991; Haas 1998).

Leopard dace feed on algae growing on rocks, which would explain their preference for stony areas (Peden 1991). Leopard dace are most often found in water with temperatures between 15 - 18°C (Peden 1991). Upper lethal temperature limit is 28°C (Black 1953). Life span of leopard dace is over four years.

Table 25: Summary of stream habitat and life history characteristics of leopard dace.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	S/L	S/L
Stream Gradient	-	-	1.0%	-
Depth Range	-	<1.0 m	<1.0 m	<1.0 m
Dominant Substrate	-	-	fine	fine-cobble
Dominant Cover	-	-	vegetation	
Dominant Habitat	-	-	-	-
Velocity Range	-	<0.5 m/s	<0.5 m/s	<0.5 m/s-fast
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	21.2°C	15-19°C, lethal: 28°C
Dominant Prey	-	diptera larvae	insects	insects
Duration	July	-	-	-
Size Range	-	9-36 mm	-	-
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	> 4 years

SPECKLED DACE (*Rhinichthys osculus*)

Speckled dace are restricted to western North America in the Chehalis, Deschutes, Columbia, and Colorado rivers as well as coastal and interior streams from southern California and Mexico (Scott and Crossman 1973; Lee et al. 1980). In BC, they are limited to south-central BC, in the Kettle River up to Wilkinson Creek, and Granby River a tributary of the Kettle River (Peden and Hughes 1984a; Cannings and Ptolemy 1998). Speckled dace are listed as a vulnerable species in Canada (Campbell 1998), and a Red listed species in BC (CDC 2001).

Speckled dace inhabit a range of habitats, from cool streams and rivers to warm ephemeral streams, to desert springs and lakes (Moyle 1976; Peden and Hughes 1984a, Cannings and Ptolemy 1998). In BC, adult speckled dace have been reported in slow to moderately strong flowing streams, associated with fairly clean, uniform rock habitat (Peden and Hughes 1984a) (Table 26, Appendix 26). Juvenile speckled dace have been found in the Kettle River over smooth stone substrate in slow to moderate currents and in the Granby River over clean sand substrate with some algae and vegetation (Peden and Hughes 1984a). Speckled dace were collected in the Columbia River in swift flowing shallow water (< 1 m) over cobble substrate (Gray and Dauble 2001). In lakes, speckled dace are more active at night, and least active

during the winter (Cannings and Ptolemy 1998). They are bottom feeders (Cannings and Ptolemy 1998), and in the Kettle River, are found with redside shiner and northern pikeminnow which are mid-water feeders (Peden and Hughes 1980). Speckled dace may be out-competed by a closely related species, the Umatilla dace (*R. umatilla*), in the Kettle River, downstream of the falls at Cascade, Washington (Peden and Hughes 1984a).

Spawning takes place probably during July in BC (Peden and Hughes 1984a). In New Mexico, speckled dace were observed spawning in early June, and during both spring and fall in Arizona (Minckley 1973). Kaya (1991) found that speckled dace initiate spawning behaviour when water temperatures increase to 18-24°C. In BC, summer water temperatures range between 14-18°C in areas where speckled dace are found (Peden and Hughes 1984a). Speckled dace from lakes spawn in shallow areas over gravel, or in inlet streams at the edge of riffles (Moyle 1976). Incubation lasts six days at 18-19°C (Moyle 1976). Speckled dace hatched in the summer may not mature until their second year (Peden and Hughes 1984a). Growth rate of speckled dace is greater at warmer water temperatures (Robinson and Childs 2001).

Sexual maturity probably occurs when individuals reach 40-50 mm length, or two years of age (Peden and Hughes 1984a). Adults usually die soon after spawning, although some individuals from populations in California and Wyoming live to age three.

Table 26: Summary of stream habitat and life history characteristics of speckled dace.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	S/L	S/L
Stream Gradient	-	-	-	-
Depth Range	shallow	-	-	<1.0 m
Dominant Substrate	gravel	-	sand-smooth stone	clean uniform rock-cobble
Dominant Cover	-	-	algae, vegetation	-
Dominant Habitat	riffle	-	-	-
Velocity Range	-	-	slow-moderate	slow-moderate
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	14-24°C	-	-	-
Dominant Prey	-	-	-	-
Duration	June-July	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	2 years	-
Maximum Age	-	-	-	2-3 years

UMATILLA DACE (*Rhinichthys umatilla*)

The range of Umatilla dace extends to Umatilla, Oregon, Washington State in the Kettle River, and possibly in northern rivers of the Snake River drainage in Oregon and Idaho (Cannings and Ptolemy 1998). Umatilla dace are a hybrid species of speckled and leopard dace (Cannings and Ptolemy 1998). There are several populations in BC, each of which is presumably divergent from one another. They are found in the Similkameen, Kettle, Kootenay, Columbia and Slocan rivers, as well as Otter Creek (Cannings and Ptolemy 1998), although they have not been reported in Otter Creek since 1990 (Haas 1998). Collection of Umatilla dace from any location is often very sporadic (Hughes and Peden 1989; Haas 1998). In BC, Umatilla dace are Red listed (CDC 2001), and are found in sympatry with leopard dace, but prefer faster flowing water (Cannings and Ptolemy 1998) (Table 27).

Umatilla dace inhabit warm, fast flowing, clean, bouldery rivers (Hughes and Peden 1989; Peden and Orchard 1993; Cannings and Ptolemy 1998) (Appendix 27), but have been found in reservoirs in areas with large substrate and a recordable current (Hughes and Peden 1988). It is thought that Umatilla dace

use the interspaces of the boulders and rocks as refuge from variable water flows, as they are found in areas with enough flow to prevent the accumulation of fine sediments (Hughes and Peden 1989). Juveniles were found in shallow, cobble habitat, while adults were in water ≥ 1.3 m deep, associated with very large boulders (≥ 1 m diameter) (Hughes and Peden 1989; Peden and Orchard 1993). Umatilla dace are benthic, and at colder temperatures are thought to move to deeper water or deeper in the substrate (Haas 1998).

Spawning is thought to take place during spring and summer (Cannings and Ptolemy 1998), but no investigation into the reproductive behaviour or ecology of Umatilla dace has been done.

Table 27: Summary of stream habitat and life history characteristics of Umatilla dace.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S	S
Stream Gradient	-	-	-	-
Depth Range	-	-	shallow	>1.3 m
Dominant Substrate	-	-	cobble	boulder
Dominant Cover	-	-	substrate	substrate
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	fast
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	-	-
Duration	spring-summer	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	-

REDSIDE SHINER (*RICHARDSONIUS BALTEATUS*)

Redside shiners are found only in North America, west of the Rocky Mountain range, between the Peace River, western Alberta, south through BC to Nevada and Utah (Scott and Crossman 1973). Redside shiners have been introduced into the Colorado River. In BC, they occur in the upper reaches of the Nass, Skeena, Klinaklini, and Homathko rivers, and the Fraser and Columbia river drainages. Redside shiners are not found on any of the coastal islands. They inhabit relatively fast streams and tributary streams to lakes (Weisel and Newman 1951; Lindsey and Northcote 1963; Porter and Rosenfeld 1999) and lakes (Appendix 28). In the Blackwater River drainage, redside shiners were found in rivers with an average bank-full width of 32.3 m, average maximum summer temperature of 21.0°C, and average watershed gradient of 1.1% (Porter et al. 2000) (Table 28). In lakes, they inhabit the littoral-profundal zone (Beauchamp et al. 1995), and limnetic zone (Crossman 1959; Narver 1967; Scarsbrook and McDonald 1973). They feed on both drift in fast water and benthic organisms in slow water (Lindsey and Northcote 1963).

Redside shiners spawn in streams and migrate to small lake tributary streams from lakes (Lindsey and Northcote 1963). Spawning initiates when water temperatures reach 10°C in late-April. Males arrive earlier on the spawning grounds. Spawning takes place almost continuously from May to late-July or early-August in BC (Weisel and Newman 1951; Lindsey and Northcote 1963). In the Columbia River, spawning has been observed in off-channel pools at temperatures between 14.5-18°C in June and July (Gray and Dauble 2001). Redside shiner spawn in riffles over gravel substrate in shallow water (0.1 m) during the day and night (Weisel and Newman 1951; Lindsey 1953; Lindsey and Northcote 1963), or near vegetation (Carl et al. 1967). Spawning groups can be as large as 30 - 40 individuals, and males in particular spawn more than once (Weisel and Newman 1951; Lindsey and Northcote 1963). The

demersal adhesive eggs are emitted into the water and adhere to gravel and vegetation (Weisel and Newman 1951; Lindsey and Northcote 1963). Eggs hatch within three to seven days at 21 - 23°C and within 15 days at 12°C (Weisel and Newman 1951; Scott and Crossman 1973). Ten days after hatching, young-of-the-year move downstream at night to the lake (Lindsey and Northcote 1963). Size range of young-of-the-year is 5-55 mm in length (Scott and Crossman 1973).

In streams and rivers of the Nazko River drainage, BC, juvenile redside shiner are found in slow moving backwater areas in water < 0.5 m deep, over gravel substrate (Porter and Rosenfeld 1999). Adult redside shiners were found in similar habitat to the juveniles, however adults inhabited slightly faster water in glides and associated with aquatic vegetation and woody debris.

In lakes, redside shiners often associated with vegetation (Brett and Pritchard 1946b; Johannes and Larkin 1961; Scott and Crossman 1973), above the thermocline (Narver 1967). Adult and juvenile (large and small) redside shiners exhibit complex daily and seasonal horizontal and vertical migrations (Crossman 1959; Johannes and Larkin 1961). Between May and July, redside shiners can be found along fairly shallow inshore areas, where smaller fish are closer to shore then large fish (Crossman 1959; Johannes and Larkin 1961).

Upper lethal temperature limit is 25 - 28°C (Black 1953). Redside shiners mature at three years of age and the maximum age is five to six years (Lindsey and Northcote 1963). However an individual from Shumway Lake, BC was estimated to be six to seven years old (Scott and Crossman 1973). Maximum size is 180 mm in length (Scott and Crossman 1973).

Table 28: Summary of stream habitat and life history characteristics of redside shiner.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S/L	S/L	S/L
Stream Gradient	-	-	1.1%	-
Depth Range	<0.2 m	-	<0.5 m	<0.5 m
Dominant Substrate	gravel	-	gravel	gravel
Dominant Cover	vegetation	-	vegetation	vegetation, woody debris
Dominant Habitat	-	-	backwater	-
Velocity Range	-	-	slow	fast
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	14.5-18°C	-	-	21-28°C
Dominant Prey	-	-	aquatic invertebrates	aquatic invertebrates
Duration	May-August	-	-	-
Size Range	-	5-55 mm	-	maximum: 180 mm
Age of Maturity	-	-	3 years	-
Maximum Age	-	-	-	5-7 years

TENCH (*Tinca tinca*)

Tench are native to rivers and lakes of northern Europe, and Arctic Ocean drainages of Asia (Scott and Crossman 1973). They were brought to North America for the World's Fair in Seattle in the early part of the 1900's (Dymond 1939). British Columbia is the only province in Canada where tench occur (Scott and Crossman 1973). They inhabit Osoyoos, Christina, and Tugulnuit lakes (Scott and Crossman 1973), and further north into the Columbia River and Okanagan River systems (BC Fisheries 2002). Tench are largely ignored in BC waters, but in Europe they are caught as a sport, food and pet fish (Scott and Crossman 1973). In BC, tench most likely inhabit shallow water in sandy and muddy bottomed areas of lakes (Gordan Haas, University of Alaska Museum, 245 O'Neill Building, Fairbanks, AK, USA 99775-7220, personal communication).

Information on tench biology comes from Europe. They are slow-moving and inhabit mud bottomed lakes, ponds and still waters in lower reaches of rivers which are heavily vegetated (Scott and Crossman 1973) (Table 29; Appendix 29). They spawn in shallow, weedy areas of lakes in June and July (Scott and Crossman 1973). Tench are thought to mature after four years (Scott and Crossman 1973). Tench may live between 20 - 30 years, and reach a maximum size of 60 cm (Wheeler 1969; Scott and Crossman 1973). They feed on insects and molluscs (Scott and Crossman 1973).

Table 29: Summary of stream habitat and life history characteristics of tench.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L	L	L	L,S
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	-	-	-	mud
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	slow
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	insects, molluscs
Dominant Prey	-	-	-	-
Duration	June-July	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	4 years	-
Maximum Age	-	-	-	30 years

SUCKERS (*CATOSTOMIDAE*)

LONGNOSE SUCKER (*Catostomus catostomus*)

Longnose suckers are the most widespread sucker species in North America, ranging from Labrador and Maryland to Washington and Alaska (Scott and Crossman 1973). Longnose suckers are found in the Yukon River drainage in Yukon, and throughout BC, except on the coastal islands (Scott and Crossman 1973). They are found primarily in clear, cold water lakes (Dymond and Scott 1941; Rawson 1951; Dryer 1966; Emery 1973) at great depths (Clemens et al. 1939; Rawson 1951; Dryer 1966; Scott and Crossman 1973). They are also found in rivers (Dymond and Scott 1941) and brackish waters (Scott and Crossman 1973).

Spawning takes place in lake tributary streams, or on lake shores (Scott and Crossman 1973) (Table 30). Timing of spawning depends on latitude, with more northern populations spawning later (June) than southern populations (April) (Scott and Crossman 1973; Morrow 1980). Populations in the south have a higher occurrence of individuals that spawn in successive years (Scott and Crossman 1973). Spawning occurs from ice break-up to mid-June in Great Slave Lake (Harris 1962). Migration into spawning streams begins when water temperatures reach 5°C (Scott and Crossman 1973), but ceases once temperatures reach 15°C (Harris 1962). In streams, spawning takes place over gravel and cobble substrates in 0.1 - 0.6 m of water, with a velocity of 0.3 - 0.45 m/s (Geen et al. 1966) (Appendix 30). Their spawning behaviour includes females holding in still water of streams while males wait in the fast current (Morrow 1980). The females move into fast water and will mate with one or several males over the course on an hour. The adhesive eggs are scattered, then they sink and attach to the course substrate (Scott and Crossman 1973; Morrow 1980). Adults migrate back to the lake shortly after spawning (Morrow 1980). Eggs hatch within eight days at 15°C, or 11 days at 10°C, but probably take up to two weeks within the stream (Scott and Crossman 1973).

After hatching, the young-of-the-year remain in the gravel for one to two weeks, after which they drift downstream to the lake (Geen et al. 1966; Bailey 1969; McPhail and Lindsey 1970; Scott and Crossman 1973). In the Sukunka River drainage in BC, young-of-the-year longnose suckers moved downstream between August to October, while juvenile and adult longnose suckers within the system made both upstream and downstream movements during August (Stuart and Chislett 1979). Juvenile longnose suckers from the Blackwater River watershed were found in streams with an average bank-full width 17.3 m, average maximum summer temperature of 20.6°C, and an average watershed gradient of 1.6% (Porter et al. 2000). Adult longnose suckers usually move into tributary streams only for spawning or overwintering (Harris 1962). When in streams, adults can be found in shallow areas of riffle habitat (Stuart and Chislett 1979). In a stream in the Peace River drainage in BC, longnose suckers were found in an area dominated by deep pool habitat and gravel substrates (Hopcraft et al. 1995).

Once in the lake, young-of-the-year moved into quiet, shallow water with vegetation where they acquire food and shelter (Brown and Graham 1953; Edwards 1983). Young-of-the-year longnose suckers may use boulders and rubble during the day (Edwards 1983). When still small, juvenile longnose suckers are plankton feeders and inhabit shallow weedy areas (Edwards 1983) with a slight current (Johnson 1971), but switch to benthic feeding as they grow (Bradbury et al. 1999; Morrow 1980).

Maximum age and age at sexual maturity vary greatly throughout the range. In BC, sexual maturity ranges from five to seven years of age, and spawning will continue to 10-12 years of age (Scott and Crossman 1973). Sexual maturity in Great Slave Lake was estimated at seven years of age and maximum life span at 10-12 years of age (Harris 1962), but some have been found up to 19-24 years (Keleher 1961; Scott and Crossman 1973) and 28 years of age (Tripp et al. 1981 from Tallman 1996). Size of juvenile longnose sucker in the Slave River, NWT ranges between 108-274 mm and for mature individuals 250-519 mm (Tripp et al. 1981 from Tallman 1996). Upper lethal temperature limit is 27°C (Black 1953).

Table 30: Summary of stream habitat and life history characteristics of longnose sucker.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	L/S	L/S	L/S
Stream Gradient	-	-	1.6%	-
Depth Range	0.1-0.6 m	-	-	shallow-deep
Dominant Substrate	gravel-cobble	gravel	-	gravel
Dominant Cover	-	-	-	-
Dominant Habitat	run	-	-	riffle, pool
Velocity Range	0.3-0.45 m/s	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	5-15°C	-	20.6°C	lethal: 27°C
Dominant Prey	-	plankton, benthic organisms	-	benthic invertebrates
Duration	April-June	1-2 weeks in stream	-	-
Size Range	-	10-80 mm	108-274 mm	250-519 mm, maximum: 642 mm
Age of Maturity	-	-	5-7 years	-
Maximum Age	-	-	-	24 years

Salish sucker (*Catostomus sp.*)

Salish suckers have likely arisen as a result of peripheral isolation from longnose sucker populations within the Chehalis River during the major glaciations of the Pleistocene (McPhail 1967; McPhail and Lindsey 1986; Cannings and Ptolemy 1998). Currently, Salish suckers are not considered a distinct species, although there has been no gene flow between longnose suckers and Salish suckers since the most recent glaciation (McPhail 1997b). McPhail and Taylor (1999) suggested *Catostomus carli* as the scientific name for Salish suckers. Salish suckers are considered endangered in Canada and BC (McPhail

1987; CDC 2001), because of their limited distribution and present steady decline (Haas 1998; Pearson 1998). The population decline is thought to be due to habitat loss (Pearson 1998). In BC, they are present in five stream systems in the lower Fraser River, including Bertrand, Cave, Fishtrap, Pepin creeks and the Salmon River (McPhail 1997b; Cannings and Ptolemy 1998; Pearson 1998). Salish suckers used to be present in the Little Campbell River, and Salwein Creek, although no individuals have been collected in the Little Campbell River since 1976 (McPhail 1987; Cannings and Ptolemy 1998), and Salwein Creek since 1992 (Inglis et al. 1992). Some Salish suckers were present in Howe Creek, a tributary to Bertrand Creek, however no individuals have been collected there for some time (Inglis et al. 1992; 1994). Salish suckers are present in two lakes and possibly a few rivers in the Puget Sound region of Washington state (McPhail and Taylor 1999; Cannings and Ptolemy 1998; Pearson 1998). Where present, Salish suckers are often at very low densities, so absences from collections do not necessarily mean that the fish does not occur in a location (Pearson 1998).

British Columbian populations of Salish suckers inhabit small, lowland streams and ponds, while lake-dwelling and stream-dwelling populations exist in Washington State (McPhail 1987) (Table 31). In streams, Salish suckers are most commonly found in fairly slow flowing water over sand or silt substrate associated with vegetation and overhead cover (Inglis et al. 1992) (Appendix 31). Salish suckers can inhabit fast water at a range of depths (Pearson 1998).

Spawning begins when water temperatures reach 7 - 8°C, usually in March or April (McPhail 1987), but ripe individuals have been collected during August at water temperatures ≥20°C (Inglis et al. 1992; McPhail and Taylor 1996). Spawning is over fine gravel substrate in fast flowing (≤0.5 m/s) riffle habitat (McPhail and Taylor 1996). No nest is built during spawning (Pearson 1998). The adhesive eggs are scattered over the coarse substrate (Pearson 1998). Incubation time is unknown. Young-of-the-year and juveniles prefer areas with abundant overhead cover, in habitats such as silt bottomed pools, long glides, shallow riffles (Inglis et al. 1992), and ponds (Pearson 1998). Adults are often found in riffles during spawning, and prefer slow flowing, deeper areas in pools and glides (Inglis et al. 1992), and possibly off-channel habitat during the winter (Pearson 1998). Sexual maturity is at age two for males and age three for females (McPhail and Taylor 1999). It is assumed that maximum life span is four years (McPhail 1987; Inglis et al. 1992). Lethal temperature is 26.9°C (Black 1953).

Table 31: Summary of stream habitat and life history characteristics of Salish sucker.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S	S
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	fine gravel	silt	silt	sand, silt
Dominant Cover	-	overhead	overhead	overhead, vegetation
Dominant Habitat	riffle, run	pool, riffle, run	pool, riffle, run	pool, glide, off-channel
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	7-8°C	-	-	20-26.9°C
Dominant Prey	-	-	-	-
Duration	March-April	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	female: 3 years, male: 2 years	-
Maximum Age	-	-	-	4 years

BRIDGELIP SUCKER (*Catostomus columbianus*)

Bridgelip suckers have a limited distribution in north-western North America. In BC, they occur in the Columbia River drainage in Erie and Lower Arrow lakes and the East Kootenay River, Osoyoos Lake, and the Similkameen River (Scott and Crossman 1973). They also occur in the Fraser River drainage, in Nicola Lake, the North Thompson and Quesnel rivers (including the Blackwater River) and other tributary rivers from the lower valley to Prince George (Carl et al. 1967). Elsewhere, bridgelip suckers are found in the Columbia River system in Nevada, Idaho, central Oregon and Washington states (Scott and Crossman 1973). Very little habitat and life history information is available for bridgelip suckers. The mouth structure of the bridgelip sucker suggests that it obtains food by scraping algae and invertebrates off rocks (Carl et al. 1967; Dauble 1980) (Table 32; Appendix 32).

Although present in lakes and slow, sand and mud bottomed areas of rivers, bridgelip suckers are most common in small, swift rivers that have abundant gravel to rocky substrates (Scott and Crossman 1973). In the Blackwater River watershed, bridgelip suckers were found in streams with an average bank-full width 31.0 m, average maximum summer temperature of 20.8°C, and an average watershed gradient of 1.0% (Porter et al. 2000).

Spawning is assumed to occur during spring, as ripe individuals were captured during June near Prince George, BC and young-of-the-year were collected during July in Idaho (Scott and Crossman 1973). Dauble (1980) observed them spawning in mid-April to June in the central Columbia River. Spawning is initiated when water temperatures reach 6 - 10°C, and spawning peaks at 8 - 13°C (Dauble 1980). Dauble (1980) captured newly emerged bridgelip suckers during mid-June in water 0.1 - 0.6 m deep in mud and rock bottomed pools. Juvenile and adult bridgelip suckers were collected in water 1 - 2 m deep and deeper at the tailout of pools and riffles in the main current over boulder substrate. At night, bridgelip sucker are found in shallower water (0.6-1.5 m, Dauble 1980). There is debate as to the size at which sexual maturity occurs. Smith (1966) estimated 12.7 cm, and Carl et al. (1967) stated 38.1 cm. Bridgelip suckers are known to hybridize with largescale suckers (Scott and Crossman 1973) and may hybridize with mountain suckers (Campbell 1992).

Table 32: Summary of stream habitat and life history characteristics of bridgelip sucker.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S/L	S/L	S/L
Stream Gradient	-	-	1.0%	-
Depth Range	-	0.1-0.6 m	1-2 m	0.6-2 m
Dominant Substrate	-	mud and rock	boulder	gravel-boulder
Dominant Cover	-	-	-	-
Dominant Habitat	-	pool	riffle, pool	riffle, pool
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	6-13°C	-	-	-
Dominant Prey	-	-	algae, invertebrates	algae, invertebrates
Duration	April-June	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	12.7-38.1 cm	-
Maximum Age	-	-	-	-

WHITE SUCKER (*Catostomus commersoni*)

White suckers have a large distribution across North America, from Ungava and Labrador to western Georgia and Oklahoma, north to the Mackenzie River delta (Scott and Crossman 1973). In Yukon, they

are present in some southern streams that flow into the Mackenzie River (YRR 2002). White suckers are present in the Skeena, Peace and upper Fraser rivers in north-central BC (Scott and Crossman 1973). They are commonly found in warm, shallow water in small lakes, bays of large lakes and tributary streams of lakes (Dymond and Scott 1941; Rawson 1951; Emery 1973; Scott and Crossman 1973; Kelso 1974; Johnson 1977; Lyons 1987) (Table 33).

White suckers spawn in spring (Emery 1973) between May and June in inlet or outlet streams of lakes when water temperatures reach at least 10 - 12°C (Nelson 1968c), although some individuals spawn along lake margins (Scott and Crossman 1973). In some areas, part of the population will spawn in the lake, and the other part in the tributaries (Scott and Crossman 1973). Spawning is usually in flowing water (slow to rapids) over gravel substrate, often near pools 0.6 - 1.2 m deep (Nelson 1968c, Scott and Crossman 1973) (Appendix 33). Adults form schools of one female to several males and travel close to the bottom (0.2 - 2.0 m above the bottom) during spawning (Emery 1973; Scott and Crossman 1973). The eggs are scattered over and adhere to the gravel substrate or drift to slower water (Scott and Crossman 1973). Eggs hatch in one to two weeks, and the young-of-the-year remain in the stream for one to two weeks more before drifting downstream to the lake (Scott and Crossman 1973). Young-of-the-year range in size from 12-179 mm in length (Scott and Crossman 1973).

Upon entering the lake, young-of-the-year white suckers remain in shallow water along the shore during the day (Corbett and Powles 1983; Lyons 1987) where they form schools and feed on plankton (McPhail and Lindsey 1970) and move to deeper water at night (McPhail and Lindsey 1970), or when water temperatures reach 30°C (Corbett and Powles 1983). By late summer, young-of-the-year white suckers move to the bottom (McPhail and Lindsey 1970). Juveniles inhabit shallow waters (Johnson 1977; Lyons 1987), where they feed near the surface on plankton but move to deeper areas once they reach 16 - 18 mm in length (Scott and Crossman 1973; Parsons 1975; Corbett and Powles 1983). Adults typically are benthic feeders, yet occasionally eat detritus (McPhail and Lindsey 1970; Parsons 1975; Ahlgren 1990). Adult white suckers associate with submerged woody debris (Moring et al. 1986; Hubert and Rahel 1989).

Young-of-the-year grow rapidly during their first year, and growth slows as the fish grow older, although growth rate varies greatly from lake to lake (Beamish 1970; Scott and Crossman 1973). Sexual maturity is between five to eight years of age (Scott and Crossman 1973). Maximum age seems to be 15 - 17 years of age (Beamish 1970; Scott and Crossman 1973), and maximum size is recorded as being 635 mm in length (Scott and Crossman 1973). White suckers are known to hybridize with mountain and largescale suckers (Nelson 1968c, Scott and Crossman 1973). In nine of 11 lakes sampled in BC, white suckers hybridized with largescale suckers (Nelson 1968c).

Table 33: Summary of stream habitat and life history characteristics of white sucker.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	L/S	L	L
Stream Gradient	-	-	-	-
Depth Range	0.6-1.2 m	-	-	-
Dominant Substrate	gravel	-	-	-
Dominant Cover	-	none-pelagic	-	-
Dominant Habitat	pool-rapid	-	-	
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	10-12°C	-	-	-
Dominant Prey	-	plankton	plankton	detritus, benthic organisms
Duration	May-June			
Size Range	-	12-179 mm	-	maximum: 635 mm
Age of Maturity	-	-	5-8 years	-
Maximum Age	-	-	-	17 years

LARGESCALE SUCKER (*Catostomus macrocheilus*)

Largescale suckers can be found from the Nass and Peace rivers in BC, south to the Sixes River in Oregon, western Utah and northern Nevada (Scott and Crossman 1973). The range of the largescale sucker is largely constrained within mainland BC. They occurs in the Peace River drainage, the Nass River and south to the Columbia and Fraser River drainages. Largescale suckers are absent from streams that flow into the Strait of Georgia, except for the Fraser River.

This species is most commonly found in weedy areas of lakes, in backwaters of rivers, and in stream mouths in water < 15 m deep (Clemens et al. 1939; Scott and Crossman 1973) (Table 34; Appendix 34). Largescale suckers are mainly bottom dwelling, but undergo diel migration within the water column (Scott and Crossman 1973; Dauble 1986). In the Blackwater River watershed juvenile largescale suckers were found in streams with an average bank-full width of 39.6 m, average maximum summer temperature of 21.4°C, and an average watershed gradient of 0.9%. Dauble (1986) found that all life history stages of largescale suckers utilize the mainstem, river margins and backwaters of the Hanford Reach in the Columbia River.

Spawning takes place during mid-May to late-June in central BC (Nelson 1968c), and mid-April in the lower Fraser Valley (McPhail and Lindsey 1970). Spawning usually takes place in small lake outlet or inlet streams in water 10 - 12°C (Nelson 1968c), although peak spawning in the Hanford Reach of the Columbia River occurred between 12-15°C (Dauble 1986). Spawning may occur along lake margins (McPhail and Lindsey 1970). In streams, spawning is in deep areas over sand (Nelson 1968c), over sand and gravel (Scott and Crossman 1973), or in riffles over cobble substrate in water 0.6-2.0 m deep (Dauble 1986). Eggs are adhesive and hatch within two weeks (McPhail and Lindsey 1970). Young-of-the-year from both river and lake populations are pelagic and form schools (McPhail and Lindsey 1970; Dauble 1986) often with other cyprinids. By the fall, young-of-the-year settle to the bottom and start feeding on benthic organisms amongst emergent vegetation (Clemens et al. 1939; McPhail and Lindsey 1970).

Dauble (1986) provides a thorough description of the distribution of all life history stages of largescale suckers in the Hanford Reach of the Columbia River. The location of largescale suckers within the river section depends on the size of the fish and the time of day. Small, larval largescale suckers are pelagic and are most commonly found along the river margins in low velocity areas (Dauble 1986). Larger young-of-the-year utilize areas with cobble and mud substrates in pools 10-60 cm deep and backwaters. Later in the year (August) young-of-the-year move to offshore areas, yet most catches of these fish in the

Hanford Reach were within 50 m of the shore and in water < 5 m deep. Most juvenile largescale suckers are common at depths < 1 m, but some occur over cobble substrates in backwater areas. Larger juveniles are most abundant and easier to catch at night between 1-2 m. Three times more adult largescale suckers were caught along the shallow (1-2 m) river margins at night compared to the day. Immediately after sunset, adult densities are at highest density along the river margins (< 1 m). Larger adults occur in deeper water in the main river channel (4-6 m), while smaller adults remain closer to the river margin in water 1-2 m deep. Overall, largescale suckers from Hanford Reach were transient, as only three of 707 fish caught at the end of the study in the original tagging location were recaptures (Dauble 1986).

Young-of-the-year largescale suckers feed on plankton and algae (Scott and Crossman 1973). Adults feed primarily on benthic invertebrates (Carl 1939; Ricker 1952), fish eggs (Patten and Rodman 1969), or fish (Dauble 1986). Sexual maturity is around five years for males and six years for females (McPhail and Lindsey 1970). Both sexes from a population in the Columbia River reached maturity at six to nine years of age (Dauble 1986). A maximum age of fifteen years was recorded in Wood Lake, BC (Clemens et al. 1939) and in the Columbia River where this age was thought to be an underestimation (Dauble 1986). Maximum size is 610 mm (Scott and Crossman 1973). Upper lethal temperature limit for largescale suckers is 29°C (Black 1953). Largescale suckers are known to hybridize with white suckers (Nelson 1968c), and bridgelip suckers (Scott and Crossman 1973; Dauble and Duschbom 1981).

Table 34: Summary of stream habitat and life history characteristics of largescale sucker.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	S/L	S/L
Stream Gradient	-	-	0.9%	-
Depth Range	0.6-2.0 m	<5.0 m	<2.0 m	< 6.0 m
Dominant Substrate	sand-cobble	cobble, mud	cobble	
Dominant Cover	-	pelagic	-	-
Dominant Habitat	pool, riffle	pool, margin, backwater	mainstem, margin, backwater	mainstem, margin
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	10-15°C	-	-	21.4-29°C
Dominant Prey	-	plankton, algae	-	benthic invertebrates
Duration	May-June	-	-	-
Size Range	-	-	-	maximum: 610 mm
Age of Maturity	-	-	6-9 years	-
Maximum Age	-	-	-	15 years

MOUNTAIN SUCKER (*Catostomus platyrhynchus*)

In Canada, mountain sucker are found from the Milk and Saskatchewan rivers in Saskatchewan and Alberta to a few locations in BC (Scott and Crossman 1973; Cannings and Ptolemy 1998). In the United States, they are found in parts of the Columbia, Milk, Upper Missouri, North Fork Feather, and Green rivers in Wyoming, Idaho, Washington, Oregon, Montana, South Dakota, Utah, Colorado, California and Nevada states (Cannings and Ptolemy 1998). In BC, mountain suckers are found in only a few locations in the southern region of the province (Cannings and Ptolemy 1998). Within these locations, mountain suckers are neither abundant nor widespread (Scott and Crossman 1973). They have been observed in the Tulameen River and Wolfe Creek, the mainstem Similkameen, North Thompson (near Heffley Creek), and Fraser rivers (near Herrling Island) (Scott and Crossman 1973; Cannings and Ptolemy 1998). In BC, mountain suckers are Blue listed (CDC 2001).

Mountain suckers are most commonly found in cool, small, moderate current mountain streams < 12 m wide and 1 m deep (Campbell 1992) (Table 35; Appendix 35). Within streams, mountain suckers

generally associate with a variety of substrates, from mud to boulder and rubble, and can be found near aquatic vegetation although this is not always true (Smith 1966; Campbell 1992). Preferred water temperatures range from 10 - 28°C during the summer and near 0°C in the winter (Reed 1962).

In Montana, spawning takes place in late spring to early summer (June to July), when water temperatures reach 10.5 - 18.8°C (Hauser 1969; Scott and Crossman 1973). The demersal and possibly adhesive eggs are released into the water column in riffles adjacent to pools (Hauser 1969). Once spent, adults move into deep pools with cover, and form small schools independent from other suckers (Scott and Crossman 1973). Presumably eggs take similar time to hatch as other sucker species (eight to 14 days) (Cannings and Ptolemy 1998). Young-of-the-year remain in moderate current, shallow water (< 0.4 m), such as run habitat, associated with cover (Hauser 1969). Juveniles move into deeper, vegetated side channels or pools that have very little current. Adults can be found adjacent to pools in water between 1 - 1.5 m with a current of 0.5 m/s, and associated with bank cover. Adults and juveniles feed largely on diatoms and algae (Scott and Crossman 1973).

Females mature between ages three to five, while males mature a year earlier (Hauser 1969), however males may mature after one to two years (Smith 1966). Maximum age is thought to be nine years (Hauser 1969). Maximum length is recorded at 226 m (Scott and Crossman 1973). Mountain suckers will hybridize with longnose and white suckers (Scott and Crossman 1973), and may hybridize with bridgelip suckers (Campbell 1992).

Table 35: Summary of stream habitat and life history characteristics of mountain sucker.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S	S
Stream Gradient	-	-	-	-
Depth Range	-	<0.4 m	>0.4 m	<1.5 m
Dominant Substrate	-	-	-	-
Dominant Cover	-	overhead	vegetation	undercut bank
Dominant Habitat	riffle	run	pool, side channel	pool
Velocity Range	-	moderate	slow	0.5 m/s
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	10.5-18.8°C	-	-	10-28°C
Dominant Prey	-	-	diatoms, algae	diatoms, algae
Duration	June-July	-	-	-
Size Range	-	-	-	maximum: 226 mm
Age of Maturity	-	-	2-5 years	-
Maximum Age	-	-	-	9 years

BULLHEAD CATFISHES (*ICTALURIDAE*)

BLACK BULLHEAD (*Ameiurus melas*)

Black bullheads were introduced to the Columbia River in Washington State, and have since spread into Oregon and BC (Scott and Crossman 1973). In BC, black bullheads are currently found in Osoyoos Lake, in the Okanagan River drainage and in the main Columbia River drainage to Revelstoke, BC (Scott and Crossman 1973; BC Fisheries 2002). The natural range of black bullheads is restricted to the freshwaters of North America, from Montana and New Mexico east to the Atlantic coastline and south-western Ontario (Scott and Crossman 1973). Black bullheads are more tolerant to pollutants than other bullhead species. This species is a bottom feeder, and is often found in the lower section of low gradient, small to medium sized streams, slow backwaters of larger rivers, and silty bottomed areas of lakes, and ponds (Table 36; Appendix 36).

Black bullheads spawn during the spring (May to June) and summer (June to August), depending on location (Forney 1955; Scott and Crossman 1973). Forney (1955) reported peak spawning during July in Iowa. Spawning is thought to commence once water temperatures reach 21°C (Scott and Crossman 1973). Females excavate a nest in gravel, and removes any silt and detritus, within moderately to heavily vegetated, shallow areas (Scott and Crossman 1973; Bryan et al. 1992). The males and females have an elaborate courtship ritual (Wallace 1967). Eggs are deposited in small batches within the same nest over the period of one day (Scott and Crossman 1973). Nests have been observed in water 0.75-1.5 m deep attached to bulrushes (Bryan et al. 1992). Both parents fan the eggs with their fins and guard the eggs until they hatch (Scott and Crossman 1973). At high temperatures, eggs hatch within five days. The newly hatched young-of-the-year form a loose school and stay close to the parents which will guard the young for several weeks until they reach a size of 25 mm.

Average maximum age is probably four years (Carlander 1969), but individuals up to eight or nine years of age have been recorded in Iowa (Scott and Crossman 1973). Average size for adults range between 144-305 mm, but an black bullhead 427 mm in length has been observed (Scott and Crossman 1973). Adults feed on insects and molluscs (Scott and Crossman 1973). Upper lethal temperature limit is 35°C (Black 1953).

Table 36: Summary of stream habitat and life history characteristics of black bullhead.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	S/L	S/L
Stream Gradient	-	-	-	-
Depth Range	shallow	-	-	-
Dominant Substrate	gravel	-	-	-
Dominant Cover	vegetation	-	-	-
Dominant Habitat	-	-	-	backwater
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	21°C	-	-	lethal: 35°C
Dominant Prey	-	-	-	insects, molluscs
Duration	May-August	-	-	-
Size Range	-	-	-	144-305 mm, maximum: 427 mm
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	9 years

BROWN BULLHEAD (*Ameiurus nebulosus*)

The native range of the brown bullhead extends from southern Manitoba, to the Great Lakes and Nova Scotia, south to Florida and eastern Texas (Scott and Crossman 1973). Brown bullheads were introduced to BC in the Lower Fraser River and southern Vancouver Island between Victoria and Nanaimo (Scott and Crossman 1973). Presently, they are found on Vancouver Island, the Lower Fraser River, the Okanagan River drainage and the upper Kootenay River drainage (BC Fisheries 2002). Brown bullheads are bottom feeders, and feed on invertebrates, plants and detritus (Scott and Crossman 1973). They are typically found in shallow to deep, warm water ponds, small lakes, and bays of large lakes, as well as large, slow-moving rivers that have abundant aquatic vegetation (Scott and Crossman 1973; Kelso 1974) (Table 37; Appendix 37).

In Canada, spawning takes place during May and June when water temperatures reach at least 21.1°C (Scott and Crossman 1973). In the southern range, spawning continues to September, with most populations spawning twice within a season. The male or female builds a nest in shallow water along lakes shore, bay coves or in creek mouths. Nests are built in sand or mud near cover such as rocks, trees,

or stumps. Nests have also been found in boat fenders hollow stumps, and tires. The mating pair engage in an elaborate mating ritual before the eggs are laid in the nest. Both parents remain by the nest to guard and fan the eggs. Eggs hatch within six to nine days at 20 - 23.3°C. Adults continue to guard the young-of-the-year at the nest for up to three weeks, or until they reach a size of 12.2 cm. Young-of-the-year range in size from 6-122 mm in length.

Age of sexual maturity is usually three years (Scott and Crossman 1973). Maximum age of brown bullheads is six to eight years. Average size of adults ranges between 203-356 mm, but adults can reach up 532 mm in length (Scott and Crossman 1973). Lethal water temperature is 35°C (Cairns 1956), and minimum oxygen concentration during the winter has been recorded to be 0.2 ppm (Scott and Crossman 1973).

Table 37: Summary of stream habitat and life history characteristics of brown bullhead.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L/S	L	L	L/S
Stream Gradient	-	-	-	-
Depth Range	shallow	-	-	-
Dominant Substrate	sand, mud	-	-	-
Dominant Cover	rock, woody debris	-	-	vegetation
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	slow
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	minimum: 0.2 ppm
Optimal Temp. Range	21.2°C	-	-	lethal: 35°C
Dominant Prey	-	-	-	invertebrates, plants, detritus
Duration	May-September	-	-	-
Size Range	-	6-122 mm	-	203-356 mm, maximum: 532 mm
Age of Maturity	-	-	3 years	-
Maximum Age	-	-	-	8 years

PIKE (*ESOCIDAE*)

NORTHERN PIKE (*Esox lucius*)

Northern pike are found only in freshwater and have a circumpolar distribution, from Scandinavia to Labrador (McPhail and Lindsey 1970). Northern pike are found throughout Yukon, and in the north-eastern corner of BC within the Peace River drainage downstream of the Peace River Canyon, and the headwaters of the Alsek and Taku rivers (McPhail and Lindsey 1970; Scott and Crossman 1973). They are found in Pine Lake, of the Alsek River drainage, and Taysen Lake in the Taku River drainage (McPhail and Lindsey 1970). Northern pike are a slow-water, predatory species, and are most commonly found in shallow areas of shallow lakes, marshes, backwater sloughs and sometimes slow rivers (Dymond and Scott 1941; Libosvarsky 1970; McPhail and Lindsey 1970; Johnson et al. 1977; Ford et al. 1995). They inhabit lakes that have between 60 - 80% of the lake area as littoral zone (Johnson et al. 1977), with at least 30%, but up to 80% vegetation cover (Grimm and Backx 1990; Casselman and Lewis 1996; Randall et al. 1996).

Spawning takes place during late-March and early-June (June 1970; McPhail and Lindsey 1970) in marshes and slough and sometimes in rivers (Ford et al. 1995) (Table 38; Appendix 38). When in rivers, spawners migrate to flooded marshes and wetlands or to shallow areas where the shoreline is concave (Casselman and Lewis 1996). Water depth during spawning is usually between 0.1 - 0.7 m, and averages between 0.2 - 0.4 m (Casselman and Lewis 1996). Preferred spawning substrate is well oxygenated detritus and elaborate root systems of emergent plants (Casselman and Lewis 1996), but spawning will

occur over sand to mud substrates (Scott and Crossman 1973; Holland and Huston 1984). In lakes, northern pike spawn in sheltered areas with moderate water exchange and extensive submergent or emergent vegetation, such as sedges and grasses (Threinen et al. 1966; McPhail and Lindsey 1970; Scott and Crossman 1973; Casselman and Lewis 1996).

In colder areas, spawning starts after ice break-up (McPhail and Lindsey 1970), when water temperatures are between 4.4 - 12°C (Scott and Crossman 1973; Casselman and Lewis 1996). Often during spawning one large female may be accompanied by two smaller males (Scott and Crossman 1973). The adhesive, demersal eggs are scattered over the vegetation during the day and abandoned by the parents (McPhail and Lindsey 1970; Ford et al. 1995). Eggs adhere to the mats of vegetation or stems of plants (Casselman and Lewis 1996). Eggs hatch within four to five days when temperatures are between 17.8 - 20°C, but usually take 12 - 14 days at lower temperatures (Scott and Crossman 1973). The newly hatched larvae remain attached to the vegetation for up to 10 days (Ford et al. 1995), so that they do not fall into the oxygen depleted substrate characteristic of northern pike spawning areas (Craig 1996). Young-of-the-year rear in mucky backwater areas, that are dense (40 - 90% coverage) with submergent and emergent vegetation (Holland and Huston 1984; Casselman and Lewis 1996). Submergent vegetation is preferred over emergent vegetation (Casselman and Lewis 1996) as it provides protection from predators and adverse winter conditions (Grimm 1989; Grimm 1994). As the young-of-the-year grow during their first season, they move from the shallow spawning areas to deeper water (1.0 - 2.5 m) (Casselman and Lewis 1996). Growth is rapid for the first three years, but is dependent on growing season, water temperature and food availability (Scott and Crossman 1973). Optimal temperature for growth in young-of-the-year was recorded as 22 - 23°C, and 19 - 21°C for juveniles and adults (Casselman 1978; Casselman and Lewis 1996).

As northern pike grow, they move to deeper and less vegetated areas (Libosvarsky 1970; Bregazzi and Kennedy 1980; Chapman and Mackay 1984a; 1994b; Casselman and Lewis 1996). Juvenile northern pike were captured in areas with moderate to high density of submergent vegetation and emergent vegetation (Holland and Huston 1984), while adults were found in areas with moderate to low density of submergent vegetation (Cook and Bergersen 1988; Casselman and Lewis 1996). The switch to submergent from emergent vegetation by juveniles and adults is thought to be due to their ambush feeding habits (Casselman and Lewis 1996). Juveniles and adults associate with detritus to mud substrates, yet avoid sandy areas (Diana et al. 1977; Ford et al. 1995; Casselman and Lewis 1996; Eklov 1997). Adult northern pike usually stay within the shallow, vegetated regions of the lake during spring and fall (Scott and Crossman 1973). They will move to deeper water during the summer when water temperatures increase (Scott and Crossman 1973), and during the winter as ice-cover forms, vegetation dies back and oxygen becomes depleted (Casselman 1978; Cook and Bergersen 1988; Derksen 1989). Typically this species is sedentary, although extensive spring (spawning) and fall migrations have been recorded (Scott and Crossman 1973; Ford et al. 1995).

Sexual maturity for females is at age five and males at age four in more northern lakes (Miller and Kennedy 1948), and between three to four years for females and two to three years for males in southern lakes (Scott and Crossman 1973; Gaboury 1985). Northern pike are long-lived, and may live more than 25 years in some areas (Rawson 1959; Miller and Kennedy 1948), although older specimens have been collected (see McPhail and Lindsey 1970; Scott and Crossman 1973). Size of females from the Valley River, Manitoba ranged between 441-610 mm, and males between 367-487 mm, and young-of-the-year between 120-229 mm (Gaboury 1985). Juvenile northern pike were found in water 19-21°C (Casselman and Lewis 1996).

Table 38: Summary of stream habitat and life history characteristics of northern pike.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L/S	L/S	L/S	L/S
Stream Gradient	-	-	-	-
Depth Range	0.1-0.7 m	shallow	deep	deep
Dominant Substrate	-	-	-	-
Dominant Cover	vegetation	vegetation	vegetation	vegetation
Dominant Habitat	backwater, off-channel	backwater, off-channel	backwater, off-channel	backwater, off-channel
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	4.4-12°C	-	19-21°C	-
Dominant Prey	-	macroinvertebrates	fish	fish
Duration	March-June	-	-	-
Size Range	-	120-229 mm	-	367-610 mm
Age of Maturity	-	-	female: 3-5 years, male: 2-4 years	-
Maximum Age	-	-	-	> 25 years

SMELTS (*OSMERIDAE*)

POND SMELT (*Hypomesus olidus*)

In North America, pond smelt occur in the Mackenzie River to Great Bear Lake, in the Peel River, Yukon, and along the western coast of Alaska between the Copper and Kobuk rivers (Scott and Crossman 1973). They also occur in Asia from Siberia to Korea. They are commonly found in freshwater streams and lakes.

Spawning takes place in streams or in the littoral area of ponds between May and June over organic debris (Scott and Crossman 1973) (Table 39; Appendix 39). Eggs hatch within 18 days at 10°C. Within their first year, pond smelt range in size between 30-60 mm in length, and by age two are as long as 80 mm. Adults can reach up to 185 mm in length after four years. Young-of-the-year eat rotifers, while large individuals add insects and algae to their diet.

Table 39: Summary of stream habitat and life history characteristics of pond smelt.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	S/L	S/L
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	organic debris	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	rotifers	rotifers, algae, insects	rotifers, algae, insects
Duration	May-June	-	-	-
Size Range	-	30-60 mm	60-80 mm	maximum: 185 mm
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	4 years

SURF SMELT (*Hypomesus pretiosus*)

Surf smelt are found from Monterey Bay, California to Chignik Lagoon, Alaska (Phinney and Dahlberg 68). Within Canada, surf smelt are only found within BC, in the lower Fraser River to the mouth of the Pitt River and occasionally in Pitt Lake (McPhail and Carveth 1993a). Surf smelt are typically a marine species, and spawn in in-shore marine areas (Haas 1998). The lower Fraser River is the only consistent area where surf smelt are caught in freshwater (Haas 1998). The ecology of surf smelt in freshwater is largely unknown (Table 40; Appendix 40).

Surf smelt spawn on beaches in light to moderate surf from March to May (Morrow 1980). Spawning takes place at the extreme low tide line to mid-way up the beach (Thompson et al. 1936; Yap-Chionggo 1941). One female will spawn with up to five males in the shallow (2.5 - 5 cm deep) tide water (Morrow 1980). Spawning substrate is important during site selection, and consists of coarse sand to fine gravel. The fertilized egg adhere to the substrate via a stalk (pedicle) that forms from the outer membrane of the egg. This stalk allows the egg to sway in the current to increase aeration (Morrow 1980). Eggs hatch within 8 - 11 days at 12.2 - 15.5°C. Once the larvae hatch, they are phototrophic and move towards the light. Once they are at least 3.5 cm long, some surf smelt move up into rivers to feed on aquatic invertebrates (McAllister 1963; Morrow 1980), however their stay in freshwater is presumably short-lived (Morrow 1980). Adult surf smelt are thought to move offshore, only to return to shallow water to spawn once they reach sexual maturity at age one or two (Morrow 1980). Maximum life expectancy is two years for males and three years for females.

Table 40: Summary of stream habitat and life history characteristics of surf smelt.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	O	O	O/S	O S
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	-	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	aquatic invertebrates	aquatic invertebrates
Duration	-	-	-	-
Size Range	-	-	3.5 cm	-
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	female: 3 years, male: 2 years

RAINBOW SMELT (*Osmerus mordax*)

Rainbow smelt are found along the coast of Alaska to Cape Bathurst, and along the Arctic coast in Asia and Europe (Scott and Crossman 1973; Haas 1998). Rainbow smelt also occur along the Atlantic Coast of North America from Labrador to New Jersey, and have been introduced to various locations including the Great Lakes (Scott and Crossman 1973). Rainbow smelt have a very limited distribution within BC. They are known from Barkley Sound off Vancouver Island, and in the lower reaches of the Stikine River in northern BC (Scott and Crossman 1973; McPhail and Carveth 1993a, Haas 1998). Freshwater collections have only come from the lower Stikine River (McPhail and Carveth 1993a). Rainbow smelt are anadromous, although landlocked populations do exist primarily in the Great Lakes, and along the east coast of North America (Scott and Crossman 1973; Scott and Scott 1988).

Spawning migration from the ocean or lake into rivers begins shortly after ice break-up when water temperatures reach at least 2 - 4°C, usually from March to May depending on the location (Scott and Crossman 1973; Morrow 1980). Spawning takes place when temperatures reach 8.9-18°C (Scott and Crossman 1973). Rainbow smelt migrate very short distances upstream to spawning areas, often a few hundred meters to a few kilometres (McKenzie 1964; Morrow 1980). If weather conditions are unfavourable, rainbow smelt will spawn offshore on gravel shoals in salt water (Rupp 1965; Leim and Scott 1966; Scott and Crossman 1973; Morrow 1980). Water velocity is thought to be the most important factor during spawning (Buckley 1989), as rainbow smelt are known to spawn over a range of substrates (fine gravel to boulders), and near submerged logs and vegetation (Morrow 1980). Most commonly however, spawning occurs over gravel substrate in moderately flowing water, ≤ 1.3 m deep (Scott and Crossman 1973; Bradbury et al. 1999) (Table 41; Appendix 41).

Sexual maturity is usually at age two (Morrow 1980), although the spawning population consists of three year olds and some older fish (McKenzie 1964). One female, accompanied by sometimes two males, emits their gametes into the water usually at night (Scott and Crossman 1973; Morrow 1980). After spawning, the adults immediately move back to the ocean or lake from where they originated (Scott and Crossman 1973; Morrow 1980). Adults either live to spawn another year or die after spawning (Morrow 1980). The eggs become adhesive after release, and attach to the substrate (Scott and Crossman 1973) via a stalk that is formed by the outer membrane of the egg (Rupp 1965). This stalk allows the egg to sway in the current to increase aeration (Scott and Crossman 1973; Morrow 1980). Eggs hatch within 29 days at 6 - 7°C, or 10 days at 15°C (Hoover 1936; McKenzie 1964). After the eggs hatch, the larvae slowly drift downstream to the ocean or lake where they eventually rear (McKenzie 1964; Scott and Crossman 1973; Morrow 1980; Scott and Scott 1988). By mid-August, young-of-the-year and juvenile rainbow smelt form schools over gravel and sand beaches, or within eelgrass beds (Scott and Crossman 1973; Buckley 1989). Adults feed on invertebrates and can grow to a length of 356 mm (Scott and Crossman 1973).

Table 41: Summary of stream habitat and life history characteristics of rainbow smelt.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	O/L	O/L	O/L
Stream Gradient	-	-	-	-
Depth Range	<1.3 m	-	-	-
Dominant Substrate	silt-boulder	-	-	-
Dominant Cover	submerged vegetation, woody debris	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	moderate	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	8.9-18°C	-	-	-
Dominant Prey	-	-	-	insects
Duration	March-May	-	-	-
Size Range	-	-	-	maximum: 356 mm
Age of Maturity	-	-	2 years	-
Maximum Age	-	-	-	-

LONGFIN SMELT (*Spirinchus thaleichthys*)

The distribution of longfin smelt is restricted to the Pacific coast of North America between San Francisco, California and the Gulf of Alaska (McAllister 1963) or Bristol Bay, Alaska (McPhail and Lindsey 1970). Along the BC coast, longfin smelt are absent from the coastal islands (Scott and Crossman 1973). They ascend the Taku River in northern BC (Scott and Crossman 1973) and the lower Fraser River to at least the Pitt River (McPhail and Carveth 1993a).

In BC, spawning takes place from October to December (Clemens and Wilby 1961) (Table 42). Spawning is in freshwater streams near the ocean (Clemens and Wilby 1961). Eggs hatch within 40 days at 6.9°C (Scott and Crossman 1973). By April young-of-the-year migrate downstream towards the ocean (Scott and Crossman 1973). In the ocean, longfin smelt remain nearshore, in bays and estuaries (Page and Burr 1991). Longfin smelt mature and spawn by age two to three in the southern portion of their range (Scott and Crossman 1973). Adult size ranges between 93-134 mm in length, and most adults die after spawning (Scott and Crossman 1973).

Table 42: Summary of stream habitat and life history characteristics of anadromous longfin smelt.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	O	O	O
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	-	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	-	-
Duration	October-December	-	-	-
Size Range	-	-	-	93-134 mm
Age of Maturity	-	-	2-3 years	-
Maximum Age	-	-	-	3 years

Pygmy longfin smelt, a smaller, landlocked form of the longfin smelt, exist in Harrison and Pitt lakes in the Fraser River system (McPhail and Carveth 1993a, Cannings and Ptolemy 1998), and in Lake Washington, Washington State (Scott and Crossman 1973). The pygmy longfin smelt from Pitt and Harrison lakes have arisen independently from anadromous populations following deglaciation, even though anadromous individuals can be found within Pitt Lake (McPhail and Carveth 1993b, Cannings and Ptolemy 1998). Pygmy longfin smelt likely carry out their complete life cycle within in the lake environment, as spawning locations have not been identified. Spawning is thought to occur in November and December, as young-of-the-year were found in trawl catches in March. In BC, pygmy longfin smelt are Red listed (CDC 2001).

EULACHON (*Thaleichthys pacificus*)

Throughout their range, eulachon are anadromous and primarily marine, spending up to 95% of their life within saltwater (Hay and McCarter 2000). Eulachon occur along the west coast of North America, from Klamath River, California to Bristol Bay, the Pribilof Islands and the Bering Sea, Alaska (Scott and Crossman 1973). In BC, eulachon spawn in only 14 rivers on a regular basis and another 19 rivers on an occasional basis (Hay and McCarter 2000). Some rivers include the Fraser, Skeena, Nass, Kemano, Kitlope, Kowesis and Gardner Canal. It is estimated that there are only nine distinct eulachon populations in BC, which is relatively low compared to the rest of the range. Eulachon are Blue listed in BC (CDC 2001).

Migration to spawning grounds occurs after ice break-up (Scott and Crossman 1973). Adults do not feed during the spawning migration or when in freshwater (Scott and Crossman 1973) (Table 43). Timing of spawning varies with latitude. Southern populations spawn as early as January, and northern populations spawn in May, however in BC this pattern is reversed (Barraclough 1964; Hay and McCarter 2000). In the Fraser River, eulachon spawn in April and May, while in the Nass and Skeena rivers they spawn in late February and early-March.

Eulachon are known to spawn in large, turbid rivers to small, clear streams, but all spawning rivers must have a spring freshet (Hay and McCarter 2000). The location of spawning within a single river changes from year to year (Hay and McCarter 2000), but usually eulachon move only short distances into coastal rivers and streams (Scott and Crossman 1973). Spawning occurs in lower reaches of the Fraser River (Hay and McCarter 2000). One known location is between Chilliwack and Mission, in 8 m of water over coarse sand substrate (Scott and Crossman 1973) (Appendix 42). Males arrive at the spawning grounds before females (Scott and Crossman 1973). Water temperature ranges between 4.4 - 7.8°C during spawning. There is no redd built and the adhesive eggs are scattered and abandoned by both parents. After spawning, most adults die (Hay and McCarter 2000), but some that are in good condition immediately migrate back to the ocean (Barraclough 1964). The outer membrane of the egg forms a stalk, which anchors the egg to the substrate (Hay and McCarter 2000). Eggs hatch within four weeks at 4 - 5°C. The newly hatched young-of-the-year remain in the stream only as long as it takes them to passively move downstream to the ocean (Smith and Saalfeld 1955; Scott and Crossman 1973; Hay and McCarter 2000). They range in size from 4-71 mm in length (Scott and Crossman 1973). While migrating/drifting downstream, young-of-the-year eulachon are found near the surface (Hay and McCarter 2000). Barraclough (1964) estimated sexual maturity to be at age two, while first spawning occurs at age three. Hay and McCarter (2000) reported sexual maturity to be at age three.

Table 43: Summary of stream habitat and life history characteristics of eulachon.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/O	O	O
Stream Gradient	-	-	-	-
Depth Range	8 m	-	-	-
Dominant Substrate	course sand	-	-	-
Dominant Cover	-	pelagic	-	-
Dominant Habitat	-	mainstem	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	4.4 - 7.8°C	-	-	-
Dominant Prey	no feeding	-	-	-
Duration	Feb-May	-	-	-
Size Range	-	4-71 mm	-	-
Age of Maturity	-	-	-	3 years
Maximum Age	-	-	-	11 years

SALMONIDS (*SALMONIDAE*)

CISCO (*Coregonus artedi*)

Ciscos (lake herring) are found from Labrador to the Mackenzie River system, from New York and Illinois to Alberta and Great Bear Lake (Cannings and Ptolemy 1998). In BC, cisco are Red listed (CDC 2001), as they only exist in the extreme northeast corner of the province in Maxhamish Lake within the Liard River drainage (Cannings and Ptolemy 1998).

Cisco primarily inhabit the deep waters of lakes (Rawson 1951; Ferguson 1958), but are also found in shallow lakes (McPhail and Lindsey 1970; Emery 1973; Aku et al. 1997), brackish waters (Dymond and Scott 1941) and rivers (Scott and Crossman 1973; Tallman 1996) (Table 44). In the Slave River, NWT, there are possibly two forms (white-finned and black-finned) of cisco utilizing the lower reaches of the river and the river delta with Great Slave Lake (Tallman 1996). More commonly cisco rear in lakes. In the Slave River, larval young-of-the-year cisco were caught in drift samples in the lower reach of the river in mid-May (Tallman 1996). Young ciscos are found in shallow nearshore areas (Rawson 1951),

especially at night (Emery 1973), where they feed on algae and copepods (Scott and Crossman 1973). At night, juvenile ciscos feed at or near the bottom of the nearshore area (Emery 1973). Young-of-the-year and juvenile ciscos move to deeper water (50 m) during summer when water temperatures rise (Ferguson 1958).

In lakes, spawning takes place in water 1 - 3 m in depth, but have been observed in deeper water (Scott and Crossman 1973). Spawning is over sandy or gravel substrate during late fall (September to November) as water temperatures decline (McPhail and Lindsey 1970; Scott and Crossman 1973). Eggs are deposited on the substrate and abandoned (Scott and Crossman 1973). Ciscos form large aggregations during spawning. Ciscos can reach 16 years of age (Aku and Tonn 1997), and a maximum size of 572 mm (Scott and Crossman 1973. Cisco can reach sexual maturity by age one (Tallman 1996). Average length of young-of-the-year cisco has been recorded as 104 mm and mature individuals range in size from 112-273 mm (from Tallman 1996).

Table 44: Summary of stream habitat and life history characteristics of cisco.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L	L	L/S	L/S
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	-	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	algae, copepods	-	plankton
Duration	-	-	-	-
Size Range	-	104 mm	-	112-273 mm, maximum 572 mm
Age of Maturity	-	-	1 year	-
Maximum Age	-	-	-	16 years

ARCTIC CISCO (*Coregonus autumnalis*)

The range of Arctic cisco is purely within the Arctic Ocean from Cambridge Bay, NWT to Point Barrow, Alaska in North America and within Arctic rivers in northern Europe to Asia (Scott and Crossman 1973). They are absent from the Bering Sea and ascend the Mackenzie River to Camsell Bend (McPhail and Lindsey 1970). They are commonly found in Yukon. However in BC, they only exist within the Liard River system (BC Fisheries 2002), and are Red listed (CDC 2001).

Arctic cisco are anadromous and are found in brackish waters and the lower reaches of large rivers (McPhail and Lindsey 1970). They leave salt water in the spring and summer to ascend rivers to spawn (Scott and Crossman 1973) (Table 45). They spawn in late summer and early autumn (McPhail and Lindsey 1970) between July and September (Dillinger et al. 1992) over gravel substrate in fast flowing water (Hatfield et al. 1972; Dryden et al. 1973; Scott and Crossman 1973; Dillinger et al. 1992) (Appendix 43). Arctic ciscos form large groups during spawning and emit and abandon the eggs over the substrate (Nikolsky 1969; Scott and Crossman 1973). Adults return immediately back to the ocean after spawning (Scott and Crossman 1973). Eggs hatch by spring, and the young move downstream to the estuary (Scott and Crossman 1973). Sexual maturity is reached by age five to seven in Siberia, and possibly nine to ten in other areas (Scott and Crossman 1973). The maximum age of Arctic ciscos is not known for North America, but is typically eight to nine years in Siberia (McPhail and Lindsey 1970). Maximum size is recorded as 457 mm (Scott and Crossman 1973). Adults feed on crustaceans and fish

Table 45: Summary of stream habitat and life history characteristics of Arctic cisco.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	O	O	O
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	gravel	-	-	-
Dominant Cover	-	pelagic	-	-
Dominant Habitat	-	-	-	-
Velocity Range	fast	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	-	crustaceans, fish
Duration	July-September	-	-	-
Size Range	-	-	-	maximum: 457 mm
Age of Maturity	-	-	5-10 years	-
Maximum Age	-	-	-	10 years

LAKE WHITEFISH (*Coregonus clupeaformis*)

Lake whitefish are found across North America from the Bering Sea east to Cambridge Bay, Ungava and Labrador and south to the St. Lawrence River and Great Lakes and west across to BC (McPhail and Lindsey 1970; Scott and Crossman 1973). Lake whitefish naturally occur in northern BC and Yukon lakes but are absent from the Stikine and Taku river drainages (Ford et al. 1995). In the mid-part of the 20th century, lake whitefish from eastern Canada were introduced into the Fraser, Okanagan-Columbia, and Kootenay-Columbia river systems in BC (Carl et al. 1959) in an attempt to build a commercial fishery. Recently, lake whitefish have been listed by COSEWIC as a threatened species in Lake Erie, Ontario (Campbell 1998).

Lake whitefish typically inhabit cool deep lakes (Dymond and Scott 1941; Rawson 1951; Godfrey 1955; Ford et al. 1995), but are also found in large mainstem rivers (RL&L 1997) (Table 46; Appendix 44). Two forms (a limnetic and a benthic form) of lake whitefish were presumed to exist in Dragon Lake, BC (Kirkpatrick and Selander 1979; Lindsey 1981; McPhail and Carveth 1993b), however in 1956 these two subspecies were eliminated when the lake was poisoned (Cannings and Ptolemy 1998). Divergence into limnetic and benthic forms was also described by Lindsey (1963) in Squanga Lake, Yukon, and several other subarctic and temperate lakes of North America (Pigeon et al. 1997).

Timing of spawning varies across the range and is dependent on latitude (Lindsey et al. 1970). In BC spawning occurs between mid-September to late January. Migration to the spawning grounds from Great Slave Lake, NWT start in August with spawning occurring in October in the Slave River (Tallman 1996). In Ontario, migration to spawning grounds (lake shore or rivers) begins in October as water temperatures cool to between 4.5°C and 10°C (MacKay 1963). Lake whitefish will spawn within either rivers or lakes. In rivers, spawning takes place in shallow water over gravel, cobble, boulder and sometimes sand (McPhail and Lindsey 1970; Machniak 1975; Ayles 1976; Morrow 1980; Ford et al. 1995). In the Columbia River, spawning occurs in waters > 0.5 m deep (RL&L 1997). Spawning in small lakes is generally in water < 10 m deep (Bryan and Kato 1975; Machniak 1975; Ayles 1976; Morrow 1980; Ford et al. 1995; Begout Anras et al. 1999), and in large lakes spawning can take place in water between 3 - 30 m deep (Machniak 1975; Ford et al. 1995). In lakes, lake whitefish prefer spawning on rocky reefs (McPhail and Lindsey 1970) or beaches with gravel and rubble substrate (Machniak 1975; Bodaly et al. 1984). Mud is avoided (Machniak 1975), however Bidgood (1972) reported spawning in < 1 m of water over sand-silt substrate in Alberta lakes and Bryan and Kato (1975) reported spawning in Yukon over silt and emergent vegetation. Lake whitefish are quite active on the spawning grounds and jump and thrash

about (Scott and Crossman 1973). No parental care is given to the eggs (Scott and Crossman 1973). In the Slave River, NWT, there is no observable post-spawning downstream migration back to the lake (Tallman 1996).

Young-of-the-year lake whitefish initially are limnetic feeders (copepods) and switch to benthic feeding (invertebrates) and habitat because of changes in temperature and food preferences (Rawson 1951; Reckahn 1970; Scott and Crossman 1973; Ford et al. 1995). In the Slave River, larval young-of the-year lake whitefish were caught in drift samples in the lower reach of the river in mid-May (Tallman 1996). Adult lake whitefish inhabit a range of depths (Rawson 1951; Godfrey 1955; Narver 1967; Begout Anras et al. 1999), and feed on benthic invertebrates (Scott and Crossman 1973). When in the littoral zone, adult lake whitefish associate with cobble, boulder and sand substrates.

Sexual maturity ranges between three to thirteen years for lake whitefish as timing of maturity is affected by commercial and recreational harvesting (Healey 1975), and latitude (Kennedy 1953). Typically, individuals from harvested populations grow faster and mature sooner than unexploited populations (Healey 1975). Individuals from northern populations mature later than individuals from southern populations. Individuals caught in the Columbia River range from two to ten years (RL&L 1997), while individuals from the Slave River, NWT range from four to fourteen years (Tallman 1996). Maximum age was recorded as 27 years (Scott and Crossman 1973). In the Slave River, mean length of young-of-the-year, juvenile and mature adults are 116 mm, 106-273 mm, and 290-503 mm respectively (from Tallman 1996).

Table 46: Summary of stream habitat and life history characteristics of lake whitefish.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	L	L	L
Stream Gradient	-	-	-	-
Depth Range	0.2-2.0 m	-	-	-
Dominant Substrate	sand-boulder	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	fast	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	copepods	benthic invertebrates	benthic invertebrates
Duration	September-January	-	-	-
Size Range	-	116 mm	106-273 mm	290-503 mm
Age of Maturity	-	-	3-13 years	-
Maximum Age	-	-	-	27 years

Squanga Whitefish (*Coregonus* sp.)

Closely related to the lake whitefish, Squanga whitefish exist only in four Yukon lakes the Dezadeash Lake in the Alsek River drainage, the Squanga, Little Teslin and Teenah in the Squangan Creek drainage(Bodaly et al. 1988). A population also existed in Hanson Lake in the Yukon River drainage, however that lake was poisoned in 1963 in preparation for stocking rainbow trout.

Squanga whitefish live in sympatry with lake whitefish, and are distinguished by their higher gill raker number. The two forms of whitefish are genetically and morphologically distinct, and likely reproductively isolated in these lakes. The four populations of Squanga whitefish are not monophyletically unique, and each has a rare status rating from COSEWIC. Squanga whitefish are found at all depths. In the summer, they are most often found in the pelagic zone.

Squanga whitefish mature between two to six years of age, depending on the lake. They probably spawn each year after maturation, and live up to a maximum of seven years. Like other whitefish species, Squanga whitefish are broadcast spawners and offer no parental care to the eggs. It is unclear if this form spawns within inlet or outlet streams, or if spawning is within the lake.

BERING CISCO (*Coregonus laurettae*)

Bering cisco occur in the very extreme western corner of North America in Alaska, yet their range may extend into Yukon and north-eastern Siberia (Scott and Crossman 1973). Very little is known about Bering cisco, although they are thought to be anadromous and are found in brackish lagoons (McPhail and Lindsey 1970). They likely migrate upstream during the summer to spawn in the fall, although spawning has not been observed (McPhail and Lindsey 1970). Their prey may consist of crustaceans (McPhail and Lindsey 1970).

Table 47: Summary of stream habitat and life history characteristics of Bering cisco.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S	O
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	-	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	-	crustaceans
Duration	fall	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	-

BROAD WHITEFISH (*Coregonus nasus*)

The main range of broad whitefish is in Arctic draining river systems from the Pechora River, in northern Asia to the Bering Sea, across northern Alaska to the Perry River in the NWT (Scott and Crossman 1973). In BC, broad whitefish are limited to Teslin Lake which straddles the Yukon-BC border (Canning and Ptolemy 1998). Because of their limited distribution within BC, broad whitefish are Red listed (CDC 2001).

Broad whitefish are more common in rivers and brackish water than in lakes (McPhail and Lindsey 1970; Valtonen 1970), so the presence of broad whitefish in Teslin Lake is unusual (Haas 1998). Broad whitefish may exhibit anadromous, lacustrine and possibly riverine life history strategies (Treble and Tallman 1997). Broad whitefish fisheries exist in many locations, including the Mackenzie River Delta (Treble and Tallman 1997). They feed on benthic invertebrates (Scott and Crossman 1973) (Table 48). Growth of broad whitefish is greater in the Canadian Arctic compared to Siberia (Tallman 1997).

Broad whitefish migrate upstream to spawning areas starting in July and August in the Mackenzie River and into September in the Yukon River (McPhail and Lindsey 1970). Spawning takes place between September and October or November (Cannings and Ptolemy 1998). Spawning may take place over gravel substrate (Valtonen 1970) (Appendix 45), where eggs are deposited on the substrate and abandoned by the adults (Scott and Crossman 1973).

In the Bay of Bothnia in the Central Baltic, Valtonen (1970) found that young broad whitefish utilize the top few meters of water while the adults inhabit depths of 5 - 20 m. Broad whitefish were caught in both mainstem and side channel of the Mackenzie River Delta (Treble and Tallman 1997).

In the Yenisei River, Siberia, broad whitefish mature at around age seven with the oldest individuals reaching 15 years of age (Scott and Crossman 1973). Broad whitefish up to 30 years old have been caught in the Mackenzie River (Treble and Tallman 1997). In the Mackenzie River, broad whitefish seven and 11-12 years in age ranged in size from 472-495 mm and 499-509 mm respectively. Females reach sexual maturity by ages five to seven, while males reach sexual maturity by age four.

Table 48: Summary of stream habitat and life history characteristics of broad whitefish.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S/L/O	S/L/O
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	gravel	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	mainstem, side channel	mainstem, side channel
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	-	benthic invertebrates
Duration	September-November	-	-	-
Size Range	-	-	-	472-509 mm
Age of Maturity	-	-	female: 5-7 years, male: 4 years	-
Maximum Age	-	-	-	30 years

LEAST CISCO (*Coregonus sardinella*)

Least ciscos are found from the Anadyr River, Asia westward to Cambridge Bay, NWT, and extend into Yukon, the Bering Sea and Alaska (McPhail and Lindsey 1970). In northern Canada their distribution does not extend far inland and is restricted within the Mackenzie River to Fort Simpson (McPhail and Lindsey 1970). Within BC, least cisco are only found in the most northwest corner of the province (Scott and Crossman 1973) in Teslin, Atlin and Swan lakes all within the Yukon River drainage (Cannings and Ptolemy 1998). They are Blue listed in BC (CDC 2001). The majority of information available comes from Asia.

Within the western part of their range, least cisco are abundant and inhabit large lakes and rivers and are either anadromous or freshwater resident (McPhail and Lindsey 1970) (Table 49). Anadromous populations of least cisco spawn over sand and gravel substrate in shallow areas of rivers during summer or fall and the eggs hatch the following spring (Appendix 46). In lakes, least cisco spawn over sand and gravel substrates (Cannings and Ptolemy 1998). They abandon their eggs (Scott and Crossman 1973).

Freshwater least ciscos reach a maximum age of nine, while anadromous individuals live up to 11 years (McPhail and Lindsey 1970). Maximum size is 419 mm (Scott and Crossman 1973). Resident populations feed on plankton and insect larvae (McPhail and Lindsey 1970).

Table 49: Summary of stream habitat and life history characteristics of anadromous least cisco.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	S/L	S/L/O
Stream Gradient	-	-	-	-
Depth Range	shallow	-	-	-
Dominant Substrate	gravel, sand	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	plankton, insect larvae	plankton, insect larvae
Duration	summer-fall	-	-	-
Size Range	-	-	-	maximum: 419 mm
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	11 years

CUTTHROAT TROUT (*Oncorhynchus clarki*)

The cutthroat trout species is split into as many as 14 subspecies, each morphologically and geographically distinct. There are four main, widely distributed subspecies and about 10 minor, narrowly distributed subspecies (Benke 1992). Only two of the subspecies, coastal cutthroat trout (*Oncorhynchus clarki clarki*) and westslope cutthroat trout (*O. c. lewisi*) exist in BC (Scott and Crossman 1973), and none occur in Yukon. Their distributions do not overlap. Coastal cutthroat trout are found between the Eel River in northern California, and Seward, south-eastern Alaska, on the west side of the Coast and Cascade Mountain ranges (Trotter 1989). Westslope cutthroat trout occur inland from the Missouri basin in western Montana, to the Kootenay and Columbia River drainages in southern BC and the Yellowstone River drainage in central Wyoming (Scott and Crossman 1973).

Coastal cutthroat trout (*O. clarki clarki*)

In BC, coastal cutthroat trout are Blue listed (CDC 2001). They exhibit four different life history strategies. Populations can either be amphidromous, potamodromous in streams, potamodromous in lakes or stream resident (Trotter 1989). Individuals from different life history strategies may coexist within the same system and not intermix (Michael 1983). Habitat association among life history strategies is quite similar.

Amphidromous

The life history of amphidromous cutthroat trout is similar to Pacific salmon, although amphidromous cutthroat trout are iteroparous, and they do not necessarily exhibit a strict migrational routine. Unlike Pacific salmon, coastal cutthroat trout may migrate to the ocean two times before becoming sexually mature (Trotter 1989). The percentage of first-return versus second-return spawners varies among watersheds (Sumner 1953; Jones 1972; 1973; 1974; 1975; 1976; Tipping 1981; Fuss 1982). Coastal cutthroat trout may spend between one to six years within freshwater before smolting (Giger 1972) (Table 50). Timing of the first smolt depends on size, age, and the type of estuary the cutthroat trout is migrating into (Trotter 1989). Migration into fairly protected waters (e.g. bays) on average is at an earlier age (two to four years) and a relatively small size (Michael 1980; Tipping 1981). Larger (21 cm) and older (three to five years), cutthroat trout migrate into inhospitable waters that force them offshore (Fuss 1982). Migration to the ocean begins in late May to early June in Washington and Oregon (Trotter 1989), and late May to mid-July in Alaska (Armstrong 1971; Jones 1976). Ocean residency lasts only the summer.

Coastal cutthroat trout commonly stay within the estuary of their home stream, or venture along the shore up to 70 km, but usually do not go more than 3 km from shore (Jones 1976; Johnston 1981).

Timing of spawning varies with latitude, with more northern populations having later spawning (Trotter 1989). In BC, cutthroat trout spawn between February and May, and between April and May in Alaska (Jones 1972; 1973; 1974; 1975; 1976). Spawning takes place in small headwater and tributary streams (Scott and Crossman 1973). Coastal cutthroat trout travel through lakes to reach spawning grounds (Jones and Seifert 1997). Redds are approximately 30 cm by 10 - 12 cm in area (Scott and Crossman 1973), and are made in pea-sized gravel in 15 - 45 cm of water (Trotter 1989) (Appendix 47). Young-of-the-year and juvenile coastal cutthroat trout associate primarily with glide and pool type habitat (Roberge 2000). Rosenfeld and Boss (2001) found that juvenile coastal cutthroat trout require pool habitat for optimal growth. Cover used by young-of-the-year and juvenile coastal cutthroat trout includes boulder substrate, and large woody debris (Roberge 2000). During winter they may shift to slower velocity areas. Coastal cutthroat trout are found over a variety of substrate types from organic debris to boulders. Mature coastal cutthroat trout associate with pools that have woody debris and boulders and a variety of substrate types. Coastal cutthroat trout are found in riffle habitat, but prefer pool habitat.

Table 50: Summary of stream habitat and life history characteristics of amphidromous coastal cutthroat trout.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S	S/O
Stream Gradient	-	-	-	-
Depth Range	15-45 mm	-	-	-
Dominant Substrate	gravel	organic-boulder	organic-boulder	organic-boulder
Dominant Cover	-	substrate, woody debris	substrate, woody debris	substrate, woody debris
Dominant Habitat	-	pool, glide	pool, glide	pool
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	-	-
Duration	February-May	-	<6 years	summer
Size Range	-	-	-	-
Age of Maturity	-	-	130-200 mm	-
Maximum Age	-	-	-	-

Potamodromous in rivers

River potamodromous life history populations exhibit migratory behaviours to the main stem of rivers, rather than the ocean (Dimick and Merryfield 1945; Nicholas 1978; Pfeifer 1985) to feed and grow. As these populations are usually located above barriers, they are restricted from migrating to the ocean (Trotter 1989). Some potamodromous populations exist where there are no barriers to the ocean (Tomasson 1978). Potamodromous cutthroat trout use small tributary streams and upstream areas of main stem rivers as spawning sites.

Potamodromous in lakes

Lake potamodromous populations feed and grow in lakes, and spawn in small tributary streams (Trotter 1989). Migration to spawning streams is later for lake-dwelling populations than amphidromous populations (Trotter 1989). Migration to both inlet and outlet tributary streams begins in late winter or spring. Spawning takes place when water temperatures are 5 - 6°C, in February to early June depending on the location (Trotter 1989). Sexual maturity is between three to four years of age and individuals will spawn each year thereafter (Pierce 1984). Coastal cutthroat trout spend from one to three years, and

occasionally four years in the tributary stream before moving to the lake (Irving 1954; Bjornn 1961; Narver 1975; Trotter 1989). When in the lake they can be found in the littoral and limnetic zones and forage at all depths (Nilsson and Northcote 1981) on invertebrates and fish.

Stream Resident

Movement between streams and rivers is limited in stream resident populations (Wyatt 1959; June 1981; Fuss 1982; Moore and Gregory 1988) (Table 51). They may be restricted to these small streams due to competition with other salmonids (Hartman and Gill 1969). Most often they spawn within the gravel of small headwater streams (Moore and Gregory 1988), that are > 3% in slope (Montgomery et al. 1999). Following emergence, young-of-the-year move to stream margins (Moore and Gregory 1988) (Appendix 48). As they grow, coastal cutthroat trout may move farther downstream to slower water areas, although total movement is often less than 200 m (Wyatt 1959; June 1981; Fuss 1982).

Stream resident coastal cutthroat trout associate with cover, such as large woody debris, and deep water (pools) within streams (Bisson et al. 1988). They are often found in backwaters, deep pools and glides (Wilzbach and Hall 1985; Glova 1986; Bisson et al. 1988). During winter, young-of-the-year coastal cutthroat trout conceal themselves under clean, boulder substrate in shallow (< 0.5 m) stream margins (Griffith and Smith 1993).

Stream resident cutthroat trout mature at an earlier age (two to three years, June 1981), are smaller, and live shorter lives than other cutthroat trout population types (Wyatt 1959).

Table 51: Summary of stream habitat and life history characteristics of stream resident coastal cutthroat trout.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S	S
Stream Gradient	>3%	-	-	-
Depth Range	-	<0.5 m- deep pools	-	-
Dominant Substrate	gravel	-	-	-
Dominant Cover	-	substrate, woody debris	-	-
Dominant Habitat	-	pool, margin	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	-	-
Duration	-	-	2-3 years	-
Size Range	-	-	-	-
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	-

Westslope cutthroat trout (*O. clarki lewisi*)

Westslope cutthroat trout inhabit waters on the west-slope of the Rocky Mountains in the Upper Kootenay and Flathead river drainages, and tributaries to the upper Columbia River upstream of Kinbasket Reservoir (BC Fisheries 2002). There are also a few isolated populations in the Kootenay region, and the Okanagan River system at the border between the United States and Canada (BC Fisheries 2002), and the North Thompson River (Ford et al. 1995). Within BC, west-slope cutthroat trout are Blue listed (CDC 2001). Westslope cutthroat trout occur in high and low elevation lakes and streams (Ford et al. 1995). For westslope cutthroat trout to inhabit a lake, it must have inlet and outlet streams that have adequate gravel substrate for spawning (Table 52; Appendix 49). Westslope cutthroat trout exhibit

potamodromous (rivers and lakes) and lake or stream resident life history strategies similar to coastal cutthroat trout.

In general, spawning occurs in small, gravely streams (Irving 1954; Scott and Crossman 1973) beginning in February and continuing to August (Scott and Crossman 1973; Shepard et al. 1984). Both sexes defend the redd, which the female builds (Scott and Crossman 1973). Eggs incubate for three to seven weeks (Ford et al. 1995). Newly emerged young-of-the-year remain in the natal stream for a few months to several years before migrating to larger streams or lakes as adults (Shapley 1961; Liknes and Graham 1988). Within the stream, west-slope cutthroat trout use backwaters, stream margins and isolated pools, and move to deeper water as they grow (Moore and Gregory 1988). Preferred substrates include cobble, rubble, pebble and gravel near overhanging boulders and woody debris (Scarnecchia and Bergersen 1986; Moore and Gregory 1988). Juveniles prefer areas with a current velocity between 10 - 12.5 cm/s (Griffith 1972). Growth rate within lakes is greater than in streams (Shepard et al. 1984). Westslope cutthroat trout will move into overwintering habitat in streams, which consist of crevices in the substrate, when water temperatures reach 4 - 5°C (Liknes and Graham 1988). Often they will move to overwintering areas before moving into a lake (Ford et al. 1995). Timing of sexual maturity ranges from two to five years (Ford et al. 1995).

Table 52: Summary of stream habitat and life history characteristics of westslope cutthroat trout.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S	S/L
Stream Gradient	-	-	-	-
Depth Range	-	-	deep	-
Dominant Substrate	gravel	gravel-cobble	gravel-cobble	-
Dominant Cover	-	-	crevices	crevices
Dominant Habitat	-	pool, margin, backwater	pool, margin, backwater	pool, margin, backwater
Velocity Range	-	-	10-12.5 cm/s	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	4-5°C	-
Dominant Prey	-	-	-	-
Duration	February-August	-	several months – several years	-
Size Range	-	-	-	-
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	-

PINK SALMON (*Oncorhynchus gorbuscha*)

The range of pink salmon covers the Pacific Rim from northern Japan to northern California, and extends further north to the Mackenzie River in the Beaufort Sea and the Lena River in the East Siberian Sea (Scott and Crossman 1973; Heard 1991). They naturally occur along the coast of BC, yet have been introduced to Europe from Asia and to eastern Canada from western Canada (Heard 1991). Pink salmon have been reproducing naturally in the Great Lakes since 1956 (Kwain 1982). The abundance of pink salmon is highest in central and southern Alaska compared to other North American locations.

Pink salmon have a strict two-year life cycle (Heard 1991). Genetic isolation between even and odd year populations occurs in many systems (Heard 1991). There is evidence of numerous runs within a single river for a given year. In the Atnarko River, spatially and temporally discrete runs of pink salmon were observed, however genetic isolation between these runs was not determined (Hilland 1976). In BC, migration of pink salmon to the spawning grounds begins in late July, August and September (Heard 1991) (Table 53). Upstream migration is limited by their inability to navigate over steep waterfalls or high-velocity sections of streams (Heard 1991). Therefore, they generally spawn close to the ocean,

although pink salmon from the Skeena River, BC have been recorded to migrate up to 480 km from the river mouth (Godfrey et al. 1954).

Female pink salmon choose fairly uniform areas with fairly swift current to build their redds (Heard 1991) (Appendix 50). Only when males are present do the females actually start preparing the redd. Redds are usually built within riffles on clean course gravel (Heard 1991), but also are found in a mixture of sand, gravel, and cobble substrates (Lucas 1959; Bonar et al. 1989). Water depth for spawning is usually less than 1 m deep (Scott and Crossman 1973). In BC, spawning temperatures range between 8 - 15°C (Hunter 1959; Andrew and Geen 1960), and will decrease greatly when temperatures rise over 16 - 17°C (Vernon 1958; Smirnov 1975). Female pink salmon will defend their redd after spawning (Heard 1991) until they die between 10 - 13 days later (Smirnov 1975). Eggs incubate between five to eight months (Heard 1991) and hatch between December and February with peak emergence during April or May in BC (Neave 1966). Newly emergent pink salmon generally migrate directly to the ocean at night, where they often remain in the nearshore areas for several months (Levy and Northcote 1982) before moving to the open ocean (Scott and Crossman 1973). They feed on invertebrates and plankton (Scott and Crossman 1973). Young-of-the-year are > 33 mm in length. Once in the nearshore environment, pink salmon feed primarily in the littoral zone during the daylight hours (Godin 1981). Pink salmon spend the remainder of their two year life cycle at sea after which they return to their natal stream to spawn. Lethal water temperature for pink salmon is > 23.9°C (Scott and Crossman 1973).

Table 53: Summary of stream habitat and life history characteristics of pink salmon.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S/O	O	O
Stream Gradient	-	-	-	-
Depth Range	20-60 cm	-	-	-
Dominant Substrate	sand-cobble	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	riffle	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	8-15°C	-	-	lethal: > 23.9°C
Dominant Prey	-	invertebrates, plankton	-	invertebrates
Duration	July-October	>33 mm	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	2 years	-
Maximum Age	-	-	-	2 years

CHUM SALMON (*Oncorhynchus keta*)

Chum salmon natural distribution is the largest of all Pacific salmon. It extends north from the Sea of Japan to the Mackenzie River in the Beaufort Sea and the Lena River in the East Siberian Sea and south along the coast of North America to Monterey California (Scott and Crossman 1973; Salo 1991). They naturally occur along the coast of BC and in Yukon. The abundance of chum salmon is higher in North American compared to Asia (Salo 1991).

In BC, migration to the spawning grounds is stimulated by an increase in stream runoff (Salo 1991). This usually occurs in August and September along the north coast, and is as late as October to January in the lower Fraser River (Salo 1991), or as early as July in northern BC (Scott and Crossman 1973) (Table 54). Despite their large size, upstream migration of chum salmon is limited by their inability to navigate over steep areas such as fish ladders (Salo 1991). Therefore they are usually limited to reaches below large barriers (Salo 1991) often within a few kilometers (Mason 1974) to approximately 160 km (Scott and

Crossman 1973) from the estuary. In the Yukon River, chum salmon spawn nearly 2000 km from the mouth (Scott and Crossman 1973). Females select sites for spawning that are just downstream of turbulent water or in areas that have upwelling (Salo 1991). Redds are built in a mixture of small to large gravel (Sano 1959), sometimes including silt or sand (Burner 1951), at depths often less than 0.5 m deep and in fairly swift water (Johnson et al. 1971) (Appendix 51). Eggs are usually laid in water above 4°C, so to protect the eggs from freezing (Salo 1991).

The timing of emergence from gravel is primarily dependent on water temperature, and occurs between December and February (Scott and Crossman 1973). Newly emergent chum salmon fry generally migrate directly to the ocean during the night, where they can remain in the nearshore areas for several months (Mason 1974; Levy and Northcote 1982) before moving to the open ocean (Scott and Crossman 1973). Downstream migration is later in the north (Yukon River), beginning in late spring with peak migration in June and July. In the south (Fraser River), migration begins in February and continues until June (Salo 1991). Young-of-the-year chum salmon were caught in 2.0 m deep beach seines in the Harrison River between early April and late-May, with the peak downstream migration in late-April (Gregory and Levings 1998). During downstream migration chum salmon fry stay near objects that provide shade and darkness, such as submerged vegetation (Salo 1991; Gregory and Levings 1996).

The time spent in the estuary of rivers is primarily for the physiological transition to high salinity water. Chum salmon fry have been documented to exploit food from both marine and riverine environments by moving between salt and freshwater with the tides, thereby lengthening their stay within the estuary (Mason 1974). They feed on invertebrates mainly (Scott and Crossman 1973). Chum salmon can live up to four years in the ocean before returning to their natal stream to spawn (Mason 1974). They reach a maximum age of six years (Scott and Crossman 1973). Lethal water temperature for chum salmon is 23.8°C.

Table 54: Summary of stream habitat and life history characteristics of chum salmon.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S/O	O	O
Stream Gradient	-	-	-	-
Depth Range	0.5 m	2.0 m	-	-
Dominant Substrate	silt-gravel	-	-	-
Dominant Cover	-	vegetation	-	-
Dominant Habitat	-	-	-	-
Velocity Range	swift	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	4°C	-	-	-
Dominant Prey	-	invertebrates	invertebrates	invertebrates
Duration	August-January	several months	-	4 years
Size Range	-	-	-	-
Age of Maturity	-	-	3-6 years	-
Maximum Age	-	-	-	6 years

COHO SALMON (*Oncorhynchus kisutch*)

Coho salmon are evenly distributed along the west coast of North American from Point Hope, Alaska to the Sacramento River, California (Scott and Crossman 1973; Sandercock 1991). They naturally occur in rivers along the coast of BC and in Yukon. Endemic populations of coho salmon exist between the Sea of Japan and Anady River in the Bering Sea (see Sandercock 1991). The abundance of coho salmon is higher in North American compared to Asia (Salo 1991). Coho salmon spawn and rear in streams.

however lake-rearing (Swain and Holtby 1989), pond-rearing (Dolloff 1993) and lake-resident (Foerster and Ricker 1953) populations do exist in BC and Alaska.

In BC, migration to the spawning grounds can begin as early as April in the Capilano River (Sandercock 1991) and Sweltzer Creek (Foerster and Ricker 1953). The usual timing is September or October (Fraser et al. 1983). Spawning migration starts earlier (July/August) in northern latitudes (Sandercock 1991). Coho salmon may spawn along the whole length of small streams but do not usually venture farther than 250 km from the mouth of large rivers (Scott and Crossman 1973).

Spawning occurs between October and March in North America (Scott and Crossman 1973; Sandercock 1991) (Table 55). Later spawning often occurs within small, short streams (Rounsefell and Kelez 1940). The timing of upstream migration and timing of spawning are not linked. Early run coho salmon may spawn immediately within the stream or wait several months before spawning, while late run coho salmon spawn soon after getting to the spawning grounds (Sandercock 1991). Lake-resident populations do not migrate to the ocean, but spawn in tributary streams to the lake (Foerster and Ricker 1953).

Coho salmon typically spawn in channels with 1-3% slope that are characterized by pool-riffle habitat (Montgomery et al. 1999) (Appendix 52). Coho salmon redds have also been observed in plane-bed habitat. In the Skagit River, coho redds were most abundant in channels that had a high number of pools (Montgomery et al. 1999). Females select the redd sites (Sandercock 1991). Redds are usually built in shallow areas over medium to small gravel (Scott and Crossman 1973).

The timing of emergence from gravel is primarily dependent on water temperature, and can occur between December and May in BC (Sandercock 1991). At 2.2°C, eggs take 137 days to hatch (Sandercock 1991). Newly emergent coho salmon young-of-the-year move to slower areas within the stream, such as side channels, near cover structures and stream banks (Tschaplinski and Hartman 1983; Bisson et al. 1988). They may migrate directly to the ocean, but more often they remain within freshwater for up to two years (Foerster and Ricker 1953; Scott and Crossman 1973). Coho salmon residency time in freshwater is dependent on temperature, with warmer stream temperatures leading to earlier migration to the ocean (Hartman et al. 1982; Holtby 1988). Young-of-the-year and more so juvenile coho salmon feed on insects and young fish (Scott and Crossman 1973). Young-of-the-year are usually <100 mm.

Juvenile coho salmon generally rear in streams and rivers, but also use beaver ponds (Dolloff 1993) and lakes, in Alaska (Ruggerone and Rogers 1992; Bryant et al. 1996) and BC (Foerster and Ricker 1953; Bangham and Adams 1954; Peterson 1982; Swales et al. 1987; Swain and Holtby 1989). Within streams, coho salmon young-of-the-year and juveniles select deep, slow water (Taylor 1991; Rosenfeld et al. 2000a) and cover structures (Glova 1986; Taylor 1988; McMahon and Hartman 1989; Nickelson et al. 1992) such as undercut banks and large woody debris. In Kloiya Creek, BC, juvenile coho salmon were found in pools at nose velocities ranging from 0.0-0.78 m/s at depths between 0.13-0.83 m (Bravender and Shirvell 1990). Density of juvenile coho salmon has been found to be highest in off-channel habitat at velocities of < 0.3 m/s (Murphy et al.1989). Juvenile coho salmon select slow flowing areas (< 0.3 m/s) in streams to overwinter (Tschaplinski and Hartman 1983). Juveniles make both large- and small-scale movements during the winter (Roni and Quinn 2001), likely in search of suitable overwintering habitat. They move between reaches within streams (Roni and Quinn 2001), as well as into other habitats which include alcove, backwater and deep main channel pools (Bell et al. 2001). Tschaplinski and Hartman (1983) observed many juveniles in the mainstem Carnation Creek, BC moving into a tributary stream to overwinter. Movement into off-channel habitat or tributaries coincides with the first freshet, or flood of the winter (Tschaplinski and Hartman 1983; Bell et al. 2001). In Carnation Creek, juveniles moved back into the mainstem in the spring (Tschaplinski and Hartman 1983). Bell et al. (2001) found that retention of juveniles during winter flooding was higher in alcove habitats compared

to backwaters or deep, mainstem pools. Coho salmon juveniles may use lakes as overwintering areas (Peterson 1982; Swales et al. 1987). They will move out of streams during winter if suitable overwintering habitat within the stream environment is absent (Tschaplinski and Hartman 1983).

Coho salmon begin smoltification after one or two years (Scott and Crossman 1973). Downstream migration takes place between April and August (Scott and Crossman 1973; Johnston et al. 1987). Coho salmon spend either one year at sea and return to spawn in their natal streams after one year as precocious males (jacks), or more commonly they spend two years at sea (Scott and Crossman 1973). They feed on fish, molluscs and invertebrates. Maximum age is reached at 5 years and size of adults ranges from 267-762 mm. Lethal water temperature for coho salmon is 25.1°C.

Table 55: Summary of stream habitat and life history characteristics of coho salmon.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S/L	O/L
Stream Gradient	1-3%	-	-	-
Depth Range	shallow	0.5 m	<1 m	-
Dominant Substrate	gravel	-	sand-cobble	-
Dominant Cover	-	woody debris, banks, overhead	woody debris, banks, overhead	
Dominant Habitat	pool-riffle	pool, side channel	backwater, pool, riffle	-
Velocity Range	-	-	<0.78 m/s	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	insects	insects, small fish	fish, molluscs, invertebrates
Duration	October-March	-	up to 2 years	1-2 years
Size Range	-	<100 mm	-	267-762 mm
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	5 years

RAINBOW TROUT (*Oncorhynchus mykiss*)

The native range of rainbow trout extends from northern Baja California and north-west Mexico to the Kuskokwim River, Alaska primarily on the west side of the Rocky Mountain range (McPhail and Lindsey 1970; Scott and Crossman 1973). British Columbia and parts of Alberta and Yukon (McPhail and Lindsey 1970) are the only areas of Canada which support native rainbow trout. However they have been introduced in these areas as well. In BC, non-native rainbow trout have moved into the Kootenay River system (Ford et al. 1995).

There are several subspecies of *Oncorhynchus mykiss* found within its natural range, and three exist in BC (Benke 1992). Benke (1992) described these subspecies as the redband trout (*O. m. gairdneri*) found in the Columbia River drainage, the coastal rainbow trout (*O. m. irideus*), and the Athabascan rainbow trout (*O. m.* subspp.) found in the headwaters of the Mackenzie River. Taylor and Haas (1996) described 'adaptive' groupings of *O. mykiss* is BC, rather than splitting into subspecies. Rainbow trout also exhibit several life history strategies including the freshwater resident rainbow trout, the anadromous steelhead (Scott and Crossman 1973), and the large-sized land-locked Kamloops (Gerrard) trout, which exists in several BC lakes (Clemens et al. 1939; Bangham and Adams 1954; Smith 1955). The Kamloops trout inhabits lakes, yet spawns in streams in similar habitat to freshwater resident rainbow trout. Individuals exhibiting different life history strategies can inhabit the same river system, as was observed by Neave (1949) in the Cowichan River, BC. Other forms or important subpopulations of rainbow trout are reviewed by Taylor and Haas (1996).

Freshwater resident

Resident rainbow trout inhabit either lakes or streams (Table 56). Lake dwelling rainbow trout are found in a variety of lake types, but are most commonly found in deep, cold oligotrophic lakes that have inlet and outlet streams with adequate spawning habitat (Ford et al. 1995). Adult rainbow trout from large lakes are primarily piscivores, and grow to a large size. In smaller lakes, adults feed primarily on invertebrates, and are typically much smaller in size (Ford et al. 1995). In streams, the average size of rainbow trout has been shown to vary depending on elevation, with size decreasing with increasing elevation (McMichael and Pearsons 1998).

Spawning takes place during the spring between mid-March to late-June in small tributary streams to lakes and larger streams (Lindsey et al. 1959; Hartman et al. 1962; Scott and Crossman 1973), when temperatures are between 10.0-15.5°C (Scott and Crossman 1973). Redds are built in clear, silt-free cold water streams near vegetated banks (Ford et al. 1995) over fine gravel in riffles above pools (Scott and Crossman 1973) (Appendix 53). Lake shore spawning rainbow trout have been observed in New Zealand over gravel substrate at depths < 1.5 m, sometimes near beds of vegetation (Penlington 1983).

Emergence from the redd takes four to seven weeks (mid-June to mid-August, Scott and Crossman 1973; Ford et al. 1995). In streams in the Peace River drainage, rainbow trout were caught in reaches dominated by riffle and run habitat, gravel and larger substrate, and a relatively low percentage of total cover (Hopcraft et al. 1995). Cover type was dominated by boulders, deep pools and LWD (Hopcraft et al. 1995). Lethal temperature is 24°C (Black 1953), and maximum age of stream resident rainbow trout is three to four years (Scott and Crossman 1973).

Table 56: Summary of stream habitat and life history characteristics of freshwater resident rainbow trout.

	Spawning	YOY	Juvenile	Adult
Stream Ocean/Lake	S L	S L	S L	S L
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	gravel	-	-	gravel-large substrate
Dominant Cover	vegetated bank	-	-	substrate, woody debris
Dominant Habitat	riffle	-	-	run-riffle, pool
Velocity Range	-	-	-	-
Turbidity Range	-	-		-
Oxygen Range	-	-	-	-
Optimal Temp. Range	10-15.5°C	-	-	lethal 24°C
Dominant Prey	-	-	invertebrates	invertebrates
Duration	March-June	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	4 years

Anadromous

In BC, anadromous steelhead populations are found in most large coastal streams and rivers, and also extend into the upper waters of the Fraser and Thompson Rivers (Ford et al. 1995). Steelhead exhibit a similar life cycle to Pacific salmon, although they are iteroparous. In the Somass River on Vancouver Island, 9.2% of winter run steelhead, and 3.3% of summer run steelhead were repeat spawners (Horncastle 1981). Steelhead can be distinguished from freshwater resident rainbow trout by their larger size. Stream residency and timing of smoltification can take between one to four years, but more commonly between two to three years (Peven et al. 1994). In streams with slow growth rate, steelhead may remain in the stream for up to seven years. Saltwater residency can last between a few months and

four years (Burgner et al. 1992). In the Somass River on Vancouver Island, steelhead spent two years in both the stream and in the ocean before returning to spawn (Horncastle 1981).

Migration to spawning grounds is variable, with both summer (May to September) and winter (December to April) runs of steelhead in BC streams (Smith 1960; Stenton 1963; Horncastle 1981). Both summer and winter run steelhead spawn between March and May (Smith 1960; Mackey et al. 2001). Summer run steelhead wait in freshwater for up to nine months before spawning (Smith 1960). A single stream can have multiple runs within the same season (Lirette and Hooton 1986). These runs are offset from one another either spatially or temporally. For example, in the Salmon River on Vancouver Island, two winter runs of steelhead were identified (Lirette and Hooton 1986). The first run spawns before March 15 in the upper portion of the river, while the second run spawns after March 15 in the lower portion of the river. Winter run male steelhead linger on the spawning site up to four weeks longer than females (Hooton and Lirette 1986). Redd size ranges from approximately 3-13 m^2 and are made in gravel and some rubble substrate (Orcutt et al. 1968; Hunter 1973) (Table 57; Appendix 54). Velocity over the spawning grounds can range from 0.6-0.8 m/s at depths from 0.2-1.5 m (Orcutt et al. 1968; Hunter 1973).

Young-of-the-year steelhead associate with either no cover, or use woody debris and overhanging cover during rearing in pool tail-out habitat with predominately gravel and rubble substrates (Pearlstone 1976). Young-of-the-year steelhead were observed at depths up to 1.2 m, but were most often found in water < 0.35 m deep in the Big Qualicum River (Pearlstone 1976). In Idaho rivers, young-of-the-year were caught at 0.15 m over rubble (Everest and Chapman 1972). Young-of-the-year in Carnation Creek, BC moved to shallow, marginal areas of the stream and associated with the rubble substrate during the winter (Bustard 1973). Juvenile steelhead use both pool and riffle (Roper et al. 1994), and pool tail-out habitat (Pearlstone 1976). Juveniles have been observed at depths of 0.3-2.0 m over gravel, rubble, cobble, and boulder substrates, associated with log and overhead cover (Bjornn 1971; Everest and Chapman 1972; Bustard 1973; Pearlstone 1976; Bjornn and Reiser 1991; Beecher et al. 1993). In the Bridge River, BC, young-of-the-year to age two steelhead use substrate as cover during the day, and enter the water column at night to forage on drift (Bradford and Higgins 2001). Young-of-the-year and juveniles also use river margins and rest on silt and sand substrates (Bradford and Higgins 2001). Use of substrate as cover increases during the winter (Bustard 1973; Bradford and Higgins 2001).

Table 57: Summary of stream habitat and life history characteristics of anadromous steelhead trout.

	Spawning	YOY	Juvenile	Adult
Stream Ocean Lake	S	S	S	O
Stream Gradient	-	-	-	-
Depth Range	0.2-1.5 m	<1.2 m	0.3-2 m	-
Dominant Substrate	gravel-rubble	silt-boulder	silt-boulder	
Dominant Cover	-	none, overhead, woody debris, substrate	none, overhead, logs, substrate	
Dominant Habitat	-	margins	pool-riffle, margins	
Velocity Range	0.6-0.8 m/s	<0.15 m/s	-	
Turbidity Range	-	-	-	
Oxygen Range	-	-	-	
Optimal Temp. Range	-	-	-	
Dominant Prey	-	drift	drift	
Duration	March-May	-	up to 4 years	few months - 3 years
Size Range	-	2-2.6 g	13.6-46.0 g	
Age of Maturity	-	-	-	
Maximum Age	-	-	-	

SOCKEYE SALMON (*Oncorhynchus nerka*)

Sockeye salmon occur in two forms, the anadromous sockeye salmon and the freshwater lake-resident kokanee (Burgner 1991). The range of sockeye salmon, and kokanee, extends in Asia north from Hokkaido, Japan to the Anadyr River in the Bering Sea and in North America they range from the Mackenzie River in the Beaufort Sea to the Sacramento River, California (Scott and Crossman 1973; Burgner 1991). There is a population of sockeye salmon in the Yukon River, however this population is limited to the lower portion of the drainage (Scott and Crossman 1973). The life cycle of juvenile sockeye salmon is different from other Pacific salmon in that they rear in lakes rather than streams, although some stream rearing populations do occur (Woods et al. 1987).

Anadromous

Sockeye salmon juveniles rear in many lakes within BC, ranging from two to over 1000 km from the ocean, in size from an average of eight to 212 m deep, 10 to 490 km^2 and up to almost 1200 m in elevation (from Burgner 1991).

In the Fraser River, BC, migration to the spawning grounds begins in July and continues to late-August or early September (Gilhousen 1960). The run timing of specific populations within the Fraser River watershed is quite exact. For example, sockeye salmon returning to the Chilko and Stellako Rivers migrate in August while the Adams River sockeye run in September (Burgner 1991). Spawning migration is not as precise for sockeye salmon from other parts of their range. In the Skeena River drainage, sockeye salmon have been observed moving into Lakelse Lake in early-June (Brett and Pritchard 1946a). In the Columbia River, migration timing has progressively started earlier (6 days), since the 1950's due to abiotic changes caused from the damming of the river (Quinn and Adams 1996). Spawning occurs at temperatures ranging between 3-7°C (Scott and Crossman 1973).

Female sockeye salmon select the redd site, and will defend the redd until near death (Burgner 1991). Sockeye salmon spawn within tributary streams, streams between lakes and within lakes depending on the climate, topography and geology of the area (Burgner 1991). Water levels and flow in rivers between lakes are less variable and provide more favourable conditions for young-of-the-year sockeye salmon (Burgner 1991). Most of the populations within BC spawn within streams with a few exceptions from Cultus Lake, Great Central Lake, Shuswap Lake and some lakes in the Skeena River watershed (Foskett 1947; Burgner 1991).

In streams, sockeye usually spawn in water less than a metre deep (Hendry and Quinn 1997; Fukushima and Smoker 1998) (Table 58; Appendix 55). Within and between lakes, sockeye salmon spawn at varying depths (<2-16 m) and substrate sizes (Foskett 1947; Kerns and Donaldson 1968; Olsen 1968). In Iliamna Lake, Alaska, sockeye salmon spawn at 30 m on coarse sand (Olsen 1968), or in coarse rubble on a shallow beach (Kerns and Donaldson 1968). Usually, however, spawning takes place over gravel (lakes and streams, Burgner 1991). In the Fraser River watershed sockeye salmon spawn later in warmer regions nearer the ocean (October to December: Cultus, Harrison and Pitt lake populations), and earlier in colder more distance regions (August to September: the Stuart River System).

Emergence from the spawning gravel varies among lakes. Emergence usually coincides with peak in plankton abundance allowing young-of-the-year sockeye salmon to optimize feeding within the rearing lake (Goodlad et al. 1974; Burgner 1991). In the Fraser River, emergence from gravel peaks in early to mid-May (Brannon 1987). Sockeye salmon emerge at night, and move into the rearing lake from the stream in large schools (Morton and Williams 1990), or if spawned within the lake they will move to either shallow (Burgner 1991) or deep areas (Barraclough and Robinson 1972). In some cases, such as that in the Harrison River BC, upstream migration to a rearing lake is impossible because of strong rapids

or waterfalls. Harrison River sockeye salmon young-of-the-year move directly to the estuary to rear (Schaefer 1951). Young-of-the-year sockeye salmon were caught in 2.0 m deep beach seines in the Harrison River between early April and late-May, with the peak downstream migration to the estuary in late-April (Gregory and Levings 1998).

Stream rearing populations are present within the Stikine River watershed (Woods et al. 1987). Young-of-the-year rear in side channels or sloughs (Burgner 1991). Juvenile sockeye salmon use aquatic vegetation as cover against possible predators (Gregory and Levings 1996). Young-of-the-year are generally <106 mm in length (Scott and Crossman 1973).

In lakes, young-of-the-year sockeye salmon utilize the limnetic zone (Heard 1965; Dawson et al. 1973; Scarsbrook and McDonald 1973; 1975; Nunnallee and Mathisen 1974) and nearshore area soon after migration in spring (Beauchamp et al. 1995). Juvenile sockeye salmon use either the littoral zone exclusively (Chilko and Shuswap Lakes), the limnetic zone exclusively (Cultus Lake) or both areas equally (Fraser Lake) in several BC lakes (Goodlad et al. 1974) and elsewhere (Hartman and Burgner 1972; Beauchamp et al. 1995). Vertical distribution of juvenile sockeye salmon can be quite variable within and among lakes throughout the year due to changes in water clarity and depth and the stability of the thermocline. Diel vertical migration is thought to be a predatory response, so in turbid lakes, juvenile sockeye salmon may not undergo diel vertical migrations.

Sockeye salmon typically spend one year (Goodlad et al. 1974; Bryant et al. 1999) rearing in lakes before migrating to the ocean. However two and three years of freshwater residency (Ricker 1941; see Burgner 1991) are possible. Downstream migration takes place between April and July and is dependent on latitude, with more northern latitude populations migrating later (Burgner 1991). Brett and Pritchard (1946a) noted that ocean migration of young sockeye salmon from Lakelse Lake, in the Skeena River drainage, was completed by late-May. Migration to the ocean is also related to fish size and age, as larger older sockeye salmon migrate earlier than younger smaller sockeye salmon (Burgner 1991). Sockeye salmon spend either one to four years at sea, usually two to three, before returning to spawn (Burgner 1991). Maximum age is 8 years old (Scott and Crossman 1973).

Table 58: Summary of stream habitat and life history characteristics of sockeye salmon.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S L	L S	L	O L
Stream Gradient	-	-	-	
Depth Range	<1 m	2 m	-	
Dominant Substrate	gravel-cobble	-	-	
Dominant Cover	-	-	-	
Dominant Habitat	-	-	-	
Velocity Range	-	-	-	
Turbidity Range	-	-	-	
Oxygen Range	-	-	-	
Optimal Temp. Range	3-7 C		-	
Dominant Prey	-	plankton	plankton	plankton
Duration	July-December	-	1-3 years	-
Size Range	-	<106 mm	-	
Age of Maturity	-	-	3-8 years	
Maximum Age	-	-	-	8 years

Lake Resident Kokanee

Kokanee do not go to the ocean and, as a result, are much smaller than sockeye salmon. Kokanee are found in lakes where sockeye salmon rear, but they are also found in lakes that are inaccessible to the anadromous form (Burgner 1991). Some populations within BC are of regional importance due to their

potential genetic uniqueness. These populations include kokanee from the Arctic and Thutade lakes in the upper Mackenzie River drainage, kokanee from the Queen Charlotte Islands, and kokanee from Vancouver Island, particularly the northern regions (Haas 1998).

Kokanee may spawn earlier in the fall than sockeye salmon (Scott and Crossman 1973). They spawn in shallow water (< 1 m deep) in lake tributary streams or on lake beaches over gravel or cobble substrate (Scott and Crossman 1973; Burgner 1991; Ford et al. 1995) (Table 59; Appendix 56). Adults die within a few days after spawning (Ford et al. 1995). Eggs hatch by spring, with incubation time ranging from 39 days at 14.3°C, to 140 days at 4°C (see Ford et al. 1995). The newly emerged young-of-the-year will either move directly to the limnetic zone to feed on plankton, or they may reside within the littoral zone for their first year, and move out as juveniles (Ford et al. 1995). They are limnetic (Levy et al. 1991; Beauchamp et al. 1995), feeding primarily on plankton (Scott and Crossman 1973; Beacham and McDonald 1982). Kokanee exhibit diel vertical migration, where they are in shallower water at night and in deeper water during the day (Finnell and Reed 1969; Narver 1970; Levy 1991). Sexual maturity is usually at age four (Scott and Crossman 1973; Beauchamp et al. 1995). Kokanee young-of-the-year have an upper lethal temperature limit of 22°C (Black 1953), while adults have a lethal limit of 24.4°C (Scott and Crossman 1973).

Table 59: Summary of stream habitat and life history characteristics of kokanee.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	L/S	L	O/L
Stream Gradient	-	-	-	-
Depth Range	<1 m	-	-	-
Dominant Substrate	gravel-cobble	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	lethal: 22°C	-	10-15°C, lethal: 24.4°C
Dominant Prey	-	plankton	plankton	plankton
Duration	August-November	-	1-3 years (sockeye)	-
Size Range	-	-	-	-
Age of Maturity	-	-	2-5 years	-
Maximum Age	-	-	-	8 years

CHINOOK SALMON (*Oncorhynchus tshawytscha*)

Chinook salmon are found in Asia north from Hokkaido, Japan to the Anadyr River in the Bering Sea. In North America they range from north of Katzebue Sound, Alaska south to the San Joaquin River, California (Scott and Crossman 1973; Healey 1991). They naturally occur in Yukon and BC, but are most abundant along the coast of BC (Healey 1991). Chinook salmon typically inhabit large river systems (Healey 1991). Chinook salmon have been introduced into large lakes and river systems throughout Europe, eastern Canada and Central and South America (Scott and Crossman 1973).

There are two main forms of chinook salmon, stream-type and ocean-type, as well as many intermediates (Healey 1991). Stream-type chinook salmon spend a larger portion of their life within freshwater, both before migration to the ocean (one to three years) and during migration to spawning grounds (several months). Ocean-type chinook salmon spend less than a year rearing in freshwater and will enter freshwater only days or weeks before spawning (Healey 1991). Stream-type chinook salmon are more frequent in the northern range (above the 56th parallel), while the ocean-type are the dominant type below the 56th parallel.

In BC, migration to the spawning grounds begins in July and continues to November (Scott and Crossman 1973). Chinook salmon returns to the Fraser River system peak in June and September although they may return as early as January (Birkenhead River) and as late as November (Harrison River) (FRAP 1995). Chinook salmon will spawn within a hundred metres of the estuary or up to 1000 km upstream in the Fraser River and 2000 km in the Yukon River (Scott and Crossman 1973). Chinook salmon spawn in May or June in the most northern part of the range, between July to September in BC and as late as November or January in the most southern locations (Healey 1991) (Table 60). Female chinook salmon select the redd site. Redds are built on gravel (Chapman 1943; Scott and Crossman 1973) and cobble substrates (Dauble et al. 1999) (Appendix 57), primarily in large rivers (Healey 1991). Chinook salmon were observed spawning in smaller tributary streams in water < 1.5 m deep at the head of riffles (Chapman 1943). Chinook salmon redds in the Skagit River were observed exclusively in channels dominated by pool-riffle habitat with < 1% slope and were most abundant in channels that had a high number of pools (Montgomery et al. 1999). In the Columbia River before the damming of the river, Chapman (1943) recorded chinook salmon spawning at depths of 5.0 m and less than 1.2 m, and Dauble et al. (1999) recorded chinook salmon spawning at depths of 4.0-8.1 m adjacent to dam outfalls. Chinook salmon will spawn on gravel shoals of lake shores or within small lake tributaries streams (Scott and Crossman 1973).

It is common for newly emergent ocean-type chinook salmon young-of-the-year to migrate directly to the ocean where they remain in the estuary or nearshore areas for several months to reach smolt size (see Healey 1991) before moving to the open ocean. Downstream migration to the estuary and ocean by juvenile chinook salmon occurs during April and May in the Fraser River, BC (Levy and Northcote 1982). Young-of-the-year chinook salmon were caught in 2.0 m deep beach seines in the Harrison River between early April and late-May, with the peak catch in late-April (Gregory and Levings 1998). In Idaho rivers, these fish were caught between 0.15-0.3 m in water flowing at <0.15 m/s (Everest and Chapman 1972). Stream-type chinook salmon will reside within freshwater for up to two years (Healey 1983), with some individuals never going to the ocean (Scott and Crossman 1973).

Preferred water temperature ranges between 12-14°C (Scott and Crossman 1973). In streams and rivers, juvenile chinook salmon associate with cobble and boulder substrates, in fairly fast flowing water < 1.0 m deep (Bravender and Shirvell 1990; Porter and Rosenfeld 1999). In Kloiya Creek, BC, juveniles were observed at depths ranging from 0.13-0.83 m in pool habitat (Bravender and Shirvell 1990). Juvenile chinook salmon were observed higher in the water column in deeper water than sympatric rainbow trout in two rivers in Washington State (McMichael and Pearsons 1998). Porter et al. (2000) conducted fish and fish habitat surveys in 48 streams in the Blackwater River watershed during the summers of 1996 and 1997. Juvenile chinook salmon were found in 19 of 48 streams with an average bank-full width 20.5 m, average maximum summer temperature of 19.6°C, and an average watershed gradient of 1.2%. Juvenile chinook salmon grew larger and faster in a flooded agricultural field adjacent the lower Sacramento River, which provides evidence that off-channel habitat is important during juvenile rearing (Sommer et al. 2001). When encountered by possible predators, young-of-the-year and juvenile chinook salmon will use aquatic vegetation as cover (Gregory and Levings 1996), however under turbid conditions, perceived predation risk of juvenile chinook salmon decrease (Gregory 1993). At night (Bradford and Higgins 2001), or under turbid conditions (<810 NTU, Gregory and Northcote 1993) young-of-the-year chinook salmon were observed moving out of the substrate to forage in the water column.

Young-of-the-year chinook salmon feed on zooplankton and aquatic invertebrates in drift (Sommer et al 2001), juveniles feed on invertebrates and adults feed on fish (Scott and Crossman 1973). Chinook salmon live between one (precocious jacks) to five years (ocean-type) in the ocean before returning to their natal stream to spawn, however two to three years is more common (Scott and Crossman 1973). Maximum possible age is 9 years, and maximum length has been recorded as 149 cm.

Table 60: Summary of stream habitat and life history characteristics of chinook salmon.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S/L	O
Stream Gradient	<1%	-	1.2%	-
Depth Range	<5 m	<2 m	<1 m	-
Dominant Substrate	gravel-cobble	silt	cobble-boulder	-
Dominant Cover	-	vegetation, substrate	vegetation, substrate	-
Dominant Habitat	pool-riffle	margin	pool, run, riffle, off-channel	-
Velocity Range	-	<0.15 m/s	-	-
Turbidity Range	-	-	<810 NTU	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	zooplankton, invertebrates	invertebrates	fish
Duration	May-November	-	1-2 years, or whole life	1-4 years
Size Range	-	41.-4.5 g	-	maximum 149 cm
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	9 years

PYGMY WHITEFISH (*Prosopium coulteri*)

The pygmy whitefish occurs in several isolated and relict locations across North America (Haas 1998). The largest range of pygmy whitefish occurs across BC into western Montana and Washington states within the Columbia, Fraser, Skeena, Peace and Liard River drainages, as well as the Teslin and Alsek Rivers systems in BC and Yukon (Scott and Crossman 1973). They may be absent from the Nass, Stikine and Taku rivers (McPhail and Carveth 1993a). There are other isolated populations of pygmy whitefish in south-western Alaska in Bristol Bay and the Alaska Peninsula, and in Lake Superior (Scott and Crossman 1973).

Pygmy whitefish are known as a deep-water species (Dryer 1966). In BC, they inhabit mountain lakes and clear or silted rivers (Scott and Crossman 1973). There is little information on the spawning biology of pygmy whitefish. Spawning is thought to take place in shallow areas in streams and lakes over coarse gravel substrate where eggs are deposited and abandoned by the adults (Scott and Crossman 1973) (Table 61; Appendix 58). Spawning occurs during October and November in BC (McCart 1965), and slightly later in Montana and Lake Superior (December to January, Scott and Crossman 1973). Pygmy whitefish can live up to nine years of age in some BC lakes, and attain a size of 271 mm (Scott and Crossman 1973). This species feeds on invertebrates.

A unique form of pygmy whitefish, the giant pygmy whitefish, exists within two BC lakes, McLeese Lake and Tyhee (Maclure) Lake in the Fraser and Bulkley river drainages respectively (Cannings and Ptolemy 1998). Lack of competition with other whitefish species is thought to be the cause of the divergence in size within the pygmy whitefish populations (McCart 1965). The larger form of the pygmy whitefish (up to twice as large) evolved separately within the two lakes and therefore has not yet been recognized as a separate species (Cannings and Ptolemy 1998). Spawning behaviour and ecology is not known for this form, however it is suspected to be similar to pygmy whitefish.

Table 61: Summary of stream habitat and life history characteristics of pygmy whitefish.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	L	L	L,S
Stream Gradient	-	-	-	-
Depth Range	shallow	-	-	-
Dominant Substrate	gravel	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	insects, molluscs, crustaceans	insects, molluscs, crustaceans
Duration	October-January	-	-	-
Size Range	-	-	-	maximum: 271 mm
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	9 years

ROUND WHITEFISH (*Prosopium cylindraceum*)

Round whitefish are distributed across most of northern and eastern Canada as well as north-eastern Asia (Scott and Crossman 1973). Round whitefish can be found from the New England states to northern New Brunswick, Labrador and Ungava west along southern Quebec and Ontario and into all of the Great Lakes (Scott and Crossman 1973; Cudmore-Vokey and Crossman 2000). They are found in isolated locations in Connecticut, and along the Ontario-Manitoba border (Scott and Crossman 1973). From northern Manitoba to Alaska, round whitefish distribution is more continuous. They are found throughout Yukon (YRR 2002), and are limited to the northern portion of BC (Scott and Crossman 1973).

Round whitefish are a bottom feeding species and feed primarily on benthic invertebrates, snails and fish eggs (YRR 2002) (Table 62). They are typically found in deep lakes throughout their southern range and shallower lakes in the north (Dryer 1966; Scott and Crossman 1973). In the Great Lakes, round whitefish usually do not venture deeper than 45 m (Dryer 1966), although exceptions have been recorded (Scott and Crossman 1973). In the northern and eastern parts of their range, such as Quebec and New Brunswick, round whitefish may inhabit rivers and brackish waters.

Spawning takes place primarily in the shallows of lakes or at river mouths, and only occasionally occurs in rivers (Scott and Crossman 1973). Timing of spawning varies with latitude, with northern populations spawning earlier than southern populations. Populations in the Great Lakes, and New Hampshire have been reported to spawn during November or December (Mraz 1964; Normandeau 1969) while populations from lakes in the Northwest Territories spawn during October and November (Harper 1948). Spawning usually takes place over gravel, rubble, boulder and rock substrate in 0.1 - 2 m of water (Normandeau 1969), but can be as deep as 16 m at temperatures near 4.5°C (Scott and Crossman 1973) (Appendix 59). Others have reported spawning in shallow areas of lakes between < 1 - 14 m of water (Normandeau 1969) over silt to boulder substrate (Bryan and Kato 1972). The eggs are deposited and abandoned by the adults (Scott and Crossman 1973). Adults do not feed during spawning.

Hatching time of round whitefish is approximately 140 days at 2.2°C, with peak hatching occurring in April (Hart 1930; Normandeau 1969). Data presented in Rawson (1951) suggests that young-of-the-year and juvenile round whitefish occupy shallower waters (< 10 m deep) while older fish are found in water between 15-35 m deep in Great Slave Lake, NWT. Sexual maturity in round whitefish is within their fourth or fifth years (Normandeau 1969). Maximum age and length of round whitefish is 13 years and

561 mm respectively (Scott and Crossman 1973). The average length of round whitefish in Yukon is approximately 41 cm (YRR 2002).

Table 62: Summary of stream habitat and life history characteristics of round whitefish.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L/S	L	L	L
Stream Gradient	-	-	-	-
Depth Range	0.1-2.0 m	-	-	-
Dominant Substrate	gravel-boulder	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	fish eggs, snails, benthic organisms	fish eggs, snails, benthic organisms
Duration	October-December	-	-	-
Size Range	-	-	-	41-56 cm
Age of Maturity	-	-	-	-
Maximum Age	-	-	4-5 years	13 years

MOUNTAIN WHITEFISH (*Prosopium williamsoni*)

Mountain whitefish are found exclusively in western North America from Wyoming, Nevada, and Montana to Alberta (Milk and Saskatchewan Rivers) and northern BC (Scott and Crossman 1973; Haas 1998). They are present in all the major river drainages in BC, except the Yukon River drainage and Vancouver Island and Queen Charlotte Islands (Haas 1998). In the Blackwater River drainage in BC, mountain whitefish were found in 26 of 48 surveyed streams with an average bank-full width of 28.5 m, average maximum summer temperature of 20.5°C, and an average watershed gradient of 1.0% (Porter et al. 2000).

In Kootenay Lake, BC, two different forms of mountain whitefish exist, the pinocchio and normal forms (McPhail and Carveth 1993a). The morphological difference is attributed to differences in trophic level or genetics (McPhail and Carveth 1993a). The two forms spawn at different times in the lake, beginning in late October and finishing in early February (McPhail and Lindsey 1970).

Mountain whitefish are typically bottom feeders (Ricker 1952) and feed on benthic invertebrates and insects (Scott and Crossman 1973), however in lakes that lack an adequate bottom fauna they will feed throughout the water column (McPhail and Lindsey 1970). In North America, mountain whitefish from the Columbia River are larger for a given age compared to other allopatric populations (RL&L 1997). Maximum size recorded is 572 mm (Scott and Crossman 1973) (Table 63). They live in lakes and clear or silty rivers (McPhail and Lindsey 1970) and seem to prefer large over small streams (Scott and Crossman 1973; Ford et al. 1995). Mountain whitefish do not inhabit waters deeper than 20 m and are most commonly be found in water 4 - 6 m deep (Scott and Crossman 1973).

In BC, spawning begins in November and continues to January (McHugh 1939; McPhail and Lindsey 1970). In the Columbia River, downstream of the Keenleyside Dam, spawning was recorded between November and February, with the peak in January (RL&L 1997). In the Sheep River, Alberta, spawning begins in late-September and continues to late-October (Thompson and Davies 1976). In Montana, spawning begins in October (Brown 1952). Peak spawning temperatures range between 3-5°C (RL&L 1995; 1997). Mountain whitefish congregate into small groups (2 - 5 individuals) at dusk to spawn (Brown 1952; Hagen 1970; RL&L 1997). In streams in the Kananaskis Reservoir, spawning groups as

large as 19 individual were observed (Thompson and Davies 1976). In lakes, spawning occurs in shallow water (< 1 m, to 6 - 20 m) (Brown 1952; Hagen 1970). Eggs are laid on gravel and rubble substrate either on shallow lake shores, or in tributary streams (Brown 1952; McPhail and Lindsey 1970; Scott and Crossman 1973), and over boulder and cobble substrate upstream of riffles and rapids in large rivers (RL&L 1997) (Appendix 60). Eggs in the Columbia River drainage were collected at depths ranging between 0.5-9.0 m (RL&L 1997). Eggs are abandoned by the adults after spawning (McPhail and Lindsey 1970).

Hatching occurs after 36 days at 16.6°C (Brown 1952). Young that were spawned in river-lake systems typically move to the lake by the end of the summer (Brown 1952), where they move to deeper offshore areas when water temperatures increase (Ford et al. 1995). In the Columbia River, young-of-the-year may undergo diel movements between nearshore and offshore areas in search of food and to avoid predators (RL&L 1997). Young-of-the-year may also undergo upstream movement to overwintering grounds (RL&L 1997). Young-of-the-year caught in the Sukunka River drainage inhabited side-channel pools and riffles (Stuart and Chislett 1979), similar to populations in the Columbia River that used shallow, calm river margins, embayments and backwaters to rear (RL&L 1997). Silt and sand substrates dominate rearing areas in the Columbia River. Length of young-of-the-year ranges between 66-185 mm (Scott and Crossman 1973).

In streams in the Nazko River drainage, BC, juvenile and adult mountain whitefish were most often found in deep, fast water over gravel and cobble substrates (Porter and Rosenfeld 1999). Juveniles and adults use aquatic vegetation and submerged cover as refuge (Ford et al. 1995)

The maximum recorded age is 18 years (McPhail and Lindsey 1970). In the Columbia River, downstream of the Keenleyside Dam, maximum recorded age is 11 years (RL&L 1997). Mountain whitefish reach sexual maturity between three to four years of age (McPhail and Lindsey 1970), however in the Columbia River (RL&L 1997) and in the Kananaskis Reservoir, Alberta (Thompson and Davies 1976) maturity can occur as early as two year of age.

Table 63: Summary of stream habitat and life history characteristics of mountain whitefish.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	S/L	S/L
Stream Gradient	-	-	-	-
Depth Range	0.5-9.0 m	-	deep	deep
Dominant Substrate	gravel-boulder	silt-boulder	gravel-cobble	gravel-cobble
Dominant Cover	-	-	aquatic vegetation, submerged cover	aquatic vegetation, submerged cover
Dominant Habitat	riffle, rapid	margin, mainstem, side channel	pool, run, riffle	pool, run, riffle
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	3-5°C	-	-	20.5°C
Dominant Prey	-	-	insects	benthic organisms
Duration	September-February	-	-	-
Size Range	-	66-185 mm	-	maximum 572 mm
Age of Maturity	-	-	2-4 years	
Maximum Age	-	-	-	18 years

ATLANTIC SALMON (*Salmo salar*)

Atlantic salmon naturally occur on the Atlantic coast of North America. Their range extends from the Connecticut River north along the coast to Ungava, across to Greenland, Iceland and the west coast of

Europe to Portugal (Scott and Crossman 1973). Atlantic salmon were first transplanted to the north Pacific Coast in 1905 (MacCrimmon and Gots 1979). That and subsequent transplantation attempts were unsuccessful (Wing et al. 1992). Since the early 1970's numerous aquaculture operations of Atlantic salmon have been established on the Pacific Coast. Salmon aquaculture expanded rapidly in BC in 1985 (Heal 1985), and in 1971 in the Puget Sound (Mighell 1981). Capture of escaped Atlantic salmon in the Alaska salmon commercial fisheries was first noticed in the late 1987 (Wing et al. 1992). Since then there have been several large scale, and many more undocumented, escapes of Atlantic salmon in BC waters. It is believed that Atlantic salmon are naturally reproducing in Vancouver Island rivers, thereby providing evidence that colonization is possible (Volpe et al. 2000), especially in systems where native salmonid populations are under capacity (Volpe et al. 2001). Hybridization between Atlantic and Pacific salmon is not a threat, as hybrids are not viable (see Wing et al. 1992). However transmission of non-indigenous disease and parasites to native Pacific salmon is a concern (Wing et al. 1992). On the Atlantic coast, Gross (1998) stated that 94% of adult Atlantic salmon on the Atlantic coast are "domestic stock", meaning that the aquaculture populations may almost constitute their own species.

On the Atlantic coast, timing of upstream spawning migration varies between May to early September, and spawning occurs between September and December (Scott and Scott 1988) (Table 64). In BC, Atlantic salmon may not spawn until January (Volpe et al. 2001). Female Atlantic salmon select gravely riffles to make their redds (Scott and Crossman 1973; Scott and Scott 1988) (Appendix 61). Atlantic salmon are iteroparous, so some adults may either remain in fresh or estuarine water for the winter, or migrate back to the ocean after spawning (Scott and Scott 1988). Eggs incubate over the winter and hatch between mid-April and mid-June. Atlantic salmon typically rear in freshwater anywhere between two to five years. Migration to the ocean takes place in May and June, and ocean residency lasts between one to three years.

When in freshwater, anadromous Atlantic salmon are most often found in streams, but there are populations that use estuarine and lacustrine habitat (Chadwick and Green 1985; Matthew et al. 1997). In streams in Atlantic Canada, young-of-the-year Atlantic salmon inhabit areas were the water velocity ranges between 5-15 cm/s (riffle habitat), in water less than 60 cm deep over cobble and gravel substrate (Morantz et al. 1987). Juveniles utilize similar habitat, but seem to move into slightly deeper and faster water (< 100 cm and 5-25 cm/s) than young-of-the-year (Morantz et al. 1987). Under experimental conditions, Atlantic salmon juveniles associate with the substrate when in competition with steelhead juveniles (Volpe et al. 2001). The preferred winter temperature range of juvenile Atlantic salmon is 6.3-7.6°C (Morgan and Metcalfe 2001).

Table 64: Summary of stream habitat and life history characteristics of Atlantic salmon.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S/L	S/L	O
Stream Gradient	-	-	-	-
Depth Range		<0.6 m	<1.0 m	-
Dominant Substrate	gravel	gravel-cobble	gravel-cobble	-
Dominant Cover	-	-	substrate	-
Dominant Habitat	riffle	riffle	riffle	-
Velocity Range	-	0.05-0.15 m/s	0.02-0.25 m/s	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	winter: 6.3-7.6°C	-
Dominant Prey	-	-	aquatic insects	crustaceans, fish
Duration	September-January	-	2-4 years	1-3 years
Size Range	-	-	-	-
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	-

BROWN TROUT (*Salmo trutta*)

Brown trout were introduced to North America from Europe and western Asia (Scott and Crossman 1973). Presently, brown trout occur on Vancouver Island, in the Okanagan River drainage and the Arrow Lakes region (BC Fisheries 2002). Anadromous or lake-dwelling populations have become established in streams and lakes where brown trout have been introduced (Scott and Crossman 1973; Bradbury et al. 1999). Most of the habitat and life history information available comes from European studies and accounts.

Often spawning takes place in streams over gravel substrate (Scott and Scott 1988), or rocky shorelines of lakes at temperatures ranging between 6.7-8.9°C (Scott and Crossman 1973) (Table 66; Appendix 62). For all types of populations, spawning begins in fall and early winter (Scott and Crossman 1973). In BC, spawning can last until January (Carl 1938). Females build a redd within the substrate, where the eggs are laid and covered with more substrate (Scott and Crossman 1973). Young-of-the-year brown trout remain within the streams for a few years before migrating to a lake to mature (Bradbury et al. 1999). Length of young-of-the-year is < 165 mm (Scott and Crossman 1973). All population types (anadromous, resident) of brown trout migrate to lakes to overwinter (Bradbury et al. 1999), although, young-of-the-year brown trout that remain within the stream conceal themselves under boulder and cobble substrate in shallow (< 0.5 m) river margins (Griffith and Smith 1993).

Within the lake, larger brown trout occupy slightly deeper and benthic regions than smaller brown trout which remain in the shallow littoral area (Bradbury et al. 1999). Smaller brown trout use boulders and rocks as cover within the littoral zone. Diel and seasonal movements between deep and shallow areas of lakes are dependent on food availability and size of brown trout. Brown trout are carnivorous (Scott and Crossman 1973). Optimal temperature range of brown trout is between 18.3 - 23.9°C (Scott and Crossman 1973). Sexual maturity is reached by age two to six years, depending on location (Bradbury et al. 1999). Maximum age of brown trout is around 10 years, however individuals up to 13 years of age have been collected (Scott and Crossman 1973; Bradbury et al. 1999).

Table 65: Summary of stream habitat and life history characteristics of brown trout.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S L	S L
Stream Gradient	-	-	-	-
Depth Range	shallow	<0.5 m	-	-
Dominant Substrate	gravel	cobble-boulder	-	-
Dominant Cover	-	substrate	-	-
Dominant Habitat	-	river margin	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	6.7-8.9°C	-	-	18.3-23.9°C
Dominant Prey	-	-	insects	insects, fish
Duration	fall-January	-	-	-
Size Range	-	< 165 mm	-	-
Age of Maturity	-	-	2-6 years	-
Maximum Age	-	-	-	13 years

ARCTIC CHAR (*Salvelinus alpinus*)

The range of Arctic char is circumpolar and is the most northerly of all freshwater fish species (Scott and Crossman 1973). Anadromous and freshwater resident populations occur in Yukon, as well as some areas in Europe, and the eastern United States (Maine, New Hampshire). Arctic char do not venture far inland

from the ocean, except in very large river systems. Arctic char have been introduced to some lakes in Yukon that are outside their natural range (YRR 2002).

Arctic char usually spawn between September and October (Table 65), although in more southern areas they spawn until December (Scott and Crossman 1973). Spawning occurs on rocky lake shores or in slow pools of rivers at depths ranging between 1.0-4.5 m when temperature are near 4°C (Appendix 63). Males are territorial and they defend a redd which they make in the substrate. Males spawn with more than one female. Once mature, females spawn every two to three years. Lethal temperature for Arctic char eggs is 7.8°C. Eggs hatch after ice-break up and young-of-the-year are about 25 mm in length. Migration back to the ocean for anadromous Arctic char is at a size between 152-203 mm or an age of five to seven years. Migration downstream occurs during the fall, and these fish usually stay within the estuary. Some anadromous Arctic char overwinter in lakes.

Size and longevity range across their distribution. In the NWT, size ranges from 318 mm at age four to 820 mm at age 21 (Scott and Crossman 1973). In Quebec, a 856 mm long Arctic char was caught. Arctic char can reach ages greater than 24 years.

Table 66: Summary of stream habitat and life history characteristics of Arctic char.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	S/L	O/L/S
Stream Gradient	-	-	-	-
Depth Range	1.0-4.5 m	-	-	-
Dominant Substrate	-	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	pool	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	4°C	-	-	-
Dominant Prey	-	-	invertebrates, fish	invertebrates, fish
Duration	September-December	-	5-7 years	-
Size Range	-	25 mm	152-203 mm	maximum: 856 mm
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	>24 years

BULL TROUT (*Salvelinus confluentus*)

Bull trout are endemic to western North America (Haas and McPhail 1991). The current distribution of bull trout extends from the southern portion of Yukon and the south-western corner of NWT, into parts of western Alberta, south to northern California and southern Nevada (Miller and Morton 1952; Scott and Crossman 1973; McPhail and Baxter 1996). The range of bull trout has shrunk in recent years due to population extinction, especially in the southern portions of their range (Carl 1985; Rode 1988; Goetz 1989; Brown 1992). Bull trout are found in the Liard River drainage in Yukon (YRR 2002). In BC, the bull trout is an interior species found on the eastern slopes of the Cascade and Coast Mountains (McPhail and Baxter 1996). They are absent from coastal waters in BC except for the Fraser and Squamish River systems (McPhail and Baxter 1996), and from the Okanagan, Similkameen and Kettle river systems (Cannings and Ptolemy 1998). In BC, declining population size has been noticed in the Columbia River drainage and the lower Fraser Valley (Hagen and Baxter 1992; Hagen 1993a; 1993b). Recently, COSWEIC listed the bull trout as a vulnerable species in Canada (Campbell 1998), and it is Blue listed in BC (CDC 2001).

Bull trout are often mistaken for Dolly Varden, *S. malma*, which are very similar in appearance but have a more coastal range (McPhail and Lindsey 1970). There are several watersheds in which the two species co-exist (e.g. Toba, Southgate, Squamish, Taku, Skeena, Stikine, Nass rivers) (Cavender 1978; Haas and McPhail 1991; Taylor et al. 2001). In 1978 the bull trout was described as a distinct species (Cavender 1978), yet hybridization between the two species does exist in some of the sympatric populations (Haas and McPhail 1991, Taylor et al. 2001).

Bull trout prefer cold, high gradient, unproductive waters (Baxter 1997). Typically, bull trout do not inhabit waters that are warmer than 15°C (Cannings and Ptolemy 1998). Bull trout exhibit four life history strategies: stream resident, fluvial-adfluvial, lacustrine-adfluvial, and anadromous (Cannings and Ptolemy 1998). Individuals exhibiting either resident or migratory life history strategies can exist within a single system (Cannings and Ptolemy 1998).

In general, spawning takes place in flowing water (Heimer 1965; McPhail and Murray 1979; Oliver 1979; Leggett 1980; Goetz 1989; Pratt 1992), presumably in high gradient (Baxter and McPhail 1996), smaller rivers and tributary streams (McPhail and Baxter 1996) (Table 66). Spawning within the main stem Liard River may take place (Stewart et al. 1982), but time spent within main stem rivers is thought to be low (McPhail and Baxter 1996). Early migrating bull trout spend several months in a spawning streams before spawning (Baxter and McPhail 1996). Spawning occurs during September and October (Cannings and Ptolemy 1998), with little variation between northern (mid-August and September) and southern (mid-September to late-October) populations (see McPhail and Baxter 1996), although an exception has been observed for different life history strategies (Brenkman et al. 2001). Temperatures ≤ 9°C are thought to trigger spawning activity in bull trout (McPhail and Murray 1979; Weaver and White 1985), while temperatures ≤ 5°C cease spawning (Allan 1987). Spawning takes place over small gravel to rubble substrate, in slow moving water (0.14-0.52 m/s), in shallow (30-60 cm) low gradient areas, near cover structures such as, undercut banks, log jams, rootwads, woody debris, pools, and overhanging vegetation (from Baxter and McPhail 1996) (Appendix 64). Velocities > 0.7 m/s are unsuitable for spawning (from Baxter and McPhail 1996). Cover is not used specifically during spawning, but is important for the adults before spawning, and for the young-of-the-year once they emerge from the redd (Baxter and McPhail 1996). In larger rivers, redds are built downstream of aggraded areas (Graham et al. 1981), near groundwater sources (Heimer 1965). Locations of groundwater upwelling are thought to be critical spawning habitat for bull trout (Baxter and McPhail 1996). Bull trout will spawn more than once, but not necessarily every year after maturation (Cannings and Ptolemy 1998).

Incubation of eggs depends on water temperature. Optimal incubation temperature is estimated at 2 - 4 °C (McPhail and Murray 1979). Young-of-the-year emerge from gravel during spring between April and May (Ratliff 1992) and stay closely associated with the bottom (McPhail and Baxter 1996). In rivers, they use shallow (< 0.5 m), low velocity areas that have ample cobble, boulder substrates, root-wads and woody debris as overhead cover (Baxter 1997). Often these areas are in side channels and pools (McPhail and Murray 1979; Pratt 1992; Allan 1987). Baxter (1997) found that juveniles use similar cover structures as young-of-the-year, but prefer root-wads. Juvenile bull trout associate with undercut banks, woody debris, and coarse substrate (Allan 1987). Habitat use varies with season and time of day (Baxter and McPhail 1996). Juveniles inhabit pool habitat during the summer, and run habitat during the fall (McPhail and Baxter 1996). At night, juvenile bull trout do not associate with cover. During the day, they prefer cobble and boulder substrate in slightly shallower water and at night they prefer open, deeper and faster areas over silt substrate (Baxter and McPhail 1997). In-stream velocity preferred by young-of-the-year and juvenile bull trout ranges between 0.1-0.28 m/s, while velocities > 0.23 m/s and 0.31 m/s are not preferred (from Baxter and McPhail 1996). Rearing bull trout occur at temperatures between 5.7-13.9°C (from Baxter and McPhail 1996). Bull trout caught in several streams in the Peace River drainage, inhabited areas dominated by riffle and run habitat, large substrate (larger than gravel), and boulder, LWD, overstream vegetation and deep pool cover (Hoperaft et al 1995).

Most juveniles remain in streams for up to four years (McPhail and Murray 1979; Shepard et al. 1984; Nakano et al. 1992; Pratt 1992; Sexauer 1994) before migrating to the main stem, lake or the ocean (depending on life history strategy).

Stream resident

Stream resident individuals are often separated from other populations by physical barriers (McPhail and Baxter 1996). Resident bull trout inhabit deep pools and use cover (McPhail and Baxter 1996). Young-of-the-year and juveniles are most often associated with overhead cover, and instream wood, and are seldom away from cover (from Baxter and McPhail 1996). Resident individuals are smaller in size than other populations (McPhail and Baxter 1996), and sexual maturity is reached at an earlier age (one to two years, Robinson and McCart 1974; Craig and Bruce 1982) and smaller size than the migratory forms (Cannings and Ptolemy 1998).

Fluvial-adfluvial

Fluvial-adfluvial individuals remain in large, main stem rivers for their adult lives, except when they migrate to small tributary systems to spawn (Craig and Bruce 1982; Allan 1980; Boag 1987; Fraley and Shepard 1989; Hildebrand 1991). The opposite migration, from tributary stream to main stem, was observed in the Liard River system during the fall (Stewart et al. 1982; Craig and Bruce 1982), and may have been linked to timing of spawning (Stewart et al. 1982). In their southern and central range, adult bull trout are more constrained by water temperature so are found primarily in large pools of rivers, or at the mouths of tributary streams (Shepard et al. 1984; Buckman et al. 1992; Hagen and Baxter 1992). In the north, bull trout are not temperature constrained and as a result are found in both small and large streams and rivers (McLeod et al. 1979; Irvine and Rowland 1979; Craig and Bruce 1982). Individuals from fluvial populations obtain larger sizes than resident populations (Baxter 1995).

Lacustrine-adfluvial

Lacustrine populations of bull trout are most common in the central range of this species (McPhail and Baxter 1996). Adult bull trout are found in large, oligotrophic, high altitude lakes. Spawning takes place in tributaries streams to the lake (Carl et al. 1989; Cannings and Ptolemy 1998), and spawning migrations can be very long (Fraley and Shepard 1989). Spawning generally occurs during September and October (Cannings and Ptolemy 1998), with little variation between northern (mid-August and September) and southern (mid-September to late-October) populations (see McPhail and Baxter 1996). However, a population of lacustrine-adfluvial bull trout were observed spawning between early-October and December (Brenkman et al. 2001). Spawning may occur each year or in alternate years. Decreasing water temperatures along with increasing discharge are thought to initiate spawning migrations.

Over the course of a year, bull trout use the entire lake. Adult bull trout feed in the littoral zone during the fall and spring, and move into deep water during the summer (Goetz 1989). Adult bull trout in lakes can grow quite large, up to 7 kg and to an age of 10 - 11 years (McPhail and Murray 1979).

Anadromous

Anadromous bull trout are the least studied (McPhail and Baxter 1996). Anadromous bull trout are suspected to exist within the Squamish River, BC, however this has not yet been confirmed (Cannings and Ptolemy 1998).

Table 67: Summary of stream habitat and life history characteristics of bull trout (general).

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S/L	S/L	S/L/O
Stream Gradient	high	-	-	-
Depth Range	0.3-0.6 m	<1.0 m	<1.0 m	-
Dominant Substrate	gravel-rubble	cobble-boulder	silt, cobble-boulder	larger than gravel-boulder
Dominant Cover	undercut banks, woody debris, overhanging vegetation	undercut banks, woody debris, overhanging vegetation, substrate	undercut banks, woody debris, overhanging vegetation	deep pools, woody debris, overhanging vegetation
Dominant Habitat	upwelling	-	pool, run	riffle, run
Velocity Range	0.14-0.52 m/s	0.1-0.28 m/s	0.1-0.28 m/s	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	5-9°C	5.7-13.9°C	5.7-13.9°C	<15°C
Dominant Prey	-	-	-	-
Duration	September-December	-	-	-
Size Range	-	-	up to 4 years	-
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	11 years

BROOK TROUT (*Salvelinus fontinalis*)

The native range of brook trout extends from eastern Manitoba to Labrador and Newfoundland south to Georgia and the upper Mississippi River. Brook trout have been introduced into lakes and rivers throughout BC, including the Columbia, Peace, Skeena, and Okanagan river drainages and Vancouver Island (Ford et al. 1995; BC Fisheries 2002). Brook trout are endemic to North America, although they have been introduced around the world due to their appeal as a sport fish (Scott and Crossman 1973). They are typically a cold water species (Dymond and Scott 1941; Scott and Crossman 1973; Wurtsbaugh et al. 1975; Meisner 1990) inhabiting cool, clear lakes and streams (Dymond and Scott 1941; Scott and Crossman 1973; Lacasse and Magnan 1992; Ford et al. 1995), that are ≤ 20°C (Morrow 1980) (Table 67). It has been suggested that with global warming, increases in water temperature may limit the available habitat for brook trout within the southern portion of their range (Meisner 1990).

Brook trout exhibit three life history strategies, which include a stream resident form, a lake to stream freshwater form, and an anadromous form (Power 1980). The biology of anadromous and resident populations appears to be similar (Bradbury et al. 1999). Timing of sexual maturity and reproduction are the main characteristics that differ among the life history strategies (Ford et al. 1995), as populations from lake-stream systems grow larger and live longer than stream only populations (Saunders and Power 1970).

In general, spawning takes place during the late summer and fall (Scott and Crossman 1973; Ford et al. 1995) in water between 3-9°C (Morrow 1980; Quinn 1995). In the north, spawning takes place during August, while in the south, spawning continues to December (Morrow 1980).

Anadromous and Stream Resident

In anadromous populations, migration to spawning grounds commences between August to October (Ford et al. 1995). Spawning usually is in gravely headwater streams (Scott and Crossman 1973; Snucins et al. 1992; Ford et al. 1995). Brook trout growth rate decreases once turbidity levels reach 10-20 NTU (Sweka and Hartman 2001). Under similar turbidity conditions brook trout associated less with cover and substrate (Gradall and Swenson 1982). Maximum age of stream resident brook trout is four years (Saunders and Power 1970).

Lacustrine

Lake dwelling brook trout reach sexual maturity at age three and live to a maximum age of seven years (Saunders and Power 1970). Migration to spawning grounds commences between August to October (Ford et al. 1995). Spawning takes place in small outlet streams (Warrillow et al. 1997), near inlet streams (Quinn 1995), or in the lake in shallow, gravel areas that have upwelling currents (Saunders and Power 1970; Scott and Crossman 1973; Fraser 1985; Snucins et al. 1992; Ford et al. 1995; Quinn 1995) (Appendix 65). In the lake, spawning is often in shallow water < 2 m deep, but has been recorded at 7 m deep (Wurtsbaugh et al. 1975; Fraser 1985; Quinn 1995; Bradbury et al. 1999). Females often clear the redd of silt and debris before spawning (Ford et al. 1995). Fine substrates tend to deposit over the redd once the eggs have been laid (Snucins et al. 1992). Eggs usually emerge by spring, often after the first snow melt of the season (Fraser 1985; Snucins et al. 1992).

In Matamek Lake, Quebec, young-of-the-year brook trout were most closely associated with the tributary streams to the lake, rather in the lake, and during the summer, 86% of the overall population resided in the tributaries (Saunders and Power 1970). In lakes during the summer, young-of-the-year brook trout use shallow areas that have cold water springs rather than moving to deeper water (Wurtsbaugh et al. 1975), whereas juveniles move to deeper water (Bradbury et al. 1999). In ponds, the reverse pattern is seen for juveniles during the winter as they move to shallower water, and may associate with gravel, rubble and boulder substrates (O'Connell and Dempson 1996; Bradbury et al. 1999). Juvenile and young-of-the-year brook trout use areas with extensive overhead vegetation and submergent debris in the shallow areas (Wurtsbaugh et al 1975).

Table 68: Summary of stream habitat and life history characteristics of brook trout.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	S/L	S/L/O
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	gravel	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	Optimum <10 NTU	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	3-9°C	-	<20°C	<20°C
Dominant Prey	-	-	-	-
Duration	August-December	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	4 years (resident)	-
Maximum Age	-	-	-	-

DOLLY VARDEN (*Salvelinus malma*)

Dolly Varden are found along the coast south to the McCloud River in California, inland to western Montana and north to Seward, Alaska and into Asia to the Anadyr River, Russia, and the Yalu River, Korea (Scott and Crossman 1973). In BC, Dolly Varden are found in all coastal waters, including Vancouver Island and the Queen Charlotte Islands (Scott and Crossman 1973). Dolly Varden are also found farther inland in BC in the Skeena and Fraser River drainages, as well as headwater streams of the Liard and Peace rivers which span into Yukon (Scott and Crossman 1973; Haas 1998). Many coastal populations in BC are in severe decline, possibly due to habitat destruction and overfishing (Haas 1998). For this reason, Dolly Varden have been Blue listed in BC (CDC 2001).

Dolly Varden are closely related, both genetically and morphologically to bull trout (*S. confluentus*). There are several watersheds in BC where these two species co-exist (e.g. Toba, Southgate, Squamish, Taku, Skeena, Stikine, Nass rivers) (Cavender 1978; Haas and McPhail 1991; Taylor et al. 2001). Hybridization between the two species does exist in some of the sympatric populations (Haas and McPhail 1991, Taylor et al. 2001).

Dolly Varden exhibit both anadromous and freshwater resident life history strategies (Scott and Crossman 1973). However, spawning behaviour and maturation are similar in both types. Spawning begins in the fall, with spawners returning to their natal stream starting in September and ending in early-November (DeLacy and Morton 1942; Scott and Crossman 1973). Males are aggressive on the spawning grounds and defend a redd dug by a female (Scott and Crossman 1973). Spawning takes place in rivers during the day, over medium to large gravel, in moderate velocity water, at water temperature near 8°C (Scott and Crossman 1973). Adults will spawn each year, sometimes up to four consecutive years (Armstrong 1974).

Sexual maturity is reached between three to six years of age, with males usually mature a year earlier than females (Scott and Crossman 1973) (Table 68; 69). Maximum age of Dolly Varden is approximately 10-12 years (Bjornn 1961), but up to 20 years (Scott and Crossman 1973)

Resident

Dolly Varden are primarily stream resident (Bustard and Royea 1995), but lake-dwelling populations exist in some BC lakes (Ricker 1941; Andrusak and Northcote 1971). Juveniles reside in freshwater from a few months to four years before migrating to a lake (Scott and Crossman 1973). In the Sukunka River drainage BC, juveniles moved upstream in June and some moved back downstream in July and August (Stuart and Chislett 1979). Adult Dolly Varden caught in the same drainage moved upstream between August and September and make return downstream movements in May and early June. Adults are most often found in fast flowing, cold water riffles (Stuart and Chislett 1979) (Appendix 66). In the Sukunka River during the winter, a few adults were caught in a shallow, ice covered side-channel in roughly 30 cm of water.

Table 69: Summary of stream habitat and life history characteristics of resident Dolly Varden.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S/L	S/L
Stream Gradient	-	-	-	-
Depth Range	-	-	-	30 cm
Dominant Substrate	large gravel	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	riffle, side channel
Velocity Range	moderate	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	8°C	-	-	-
Dominant Prey	-	-	-	-
Duration	September-November	-	few months-4 years	-
Size Range	-	-	-	-
Age of Maturity	-	-	3-6 years	-
Maximum Age	-	-	-	20 years

Anadromous

Spawning migration into rivers from the ocean begins in May and continues to December (DeLacy and Morton 1942; Scott and Crossman1973). Anadromous Dolly Varden from the Keogh River, BC were

observed migrating upstream to spawn during July (Smith and Slaney 1980). Spawning takes place in both mainstem and tributary streams (Smith and Slaney 1980). Anadromous Dolly Varden juveniles typically reside in freshwater for three to four years before migrating to the ocean (Scott and Crossman 1973) (Table 69). Outmigration of adults and smolts occurs from March to June (Smith and Slaney 1980).

Juveniles may rear in rivers, streams or beaver ponds (Dolloff 1993). Young-of-the-year anadromous Dolly Varden from the Keogh River, BC were most commonly observed in riffle and run habitats associated with small and large gravel substrates (Smith and Slaney 1980) (Appendix 67). Juveniles from the same system were observed in riffles, runs and pool habitats (Smith and Slaney 1980). Research done in southeastern Alaska by Armstrong (1965; 1974) found that anadromous Dolly Varden from lake-stream populations (spawned in streams connected to a lake), or non-lake populations (spawned in streams not connected to a lake) exhibit a range of migrational behaviours. Individuals from lake-stream populations, leave lakes in spring and summer to migrate to the ocean for the summer, and return to the lake to overwinter (Armstrong 1974), while other individuals migrate to non-lake streams (Armstrong 1965). The opposite is true for individuals from non-lake populations. These individuals enter the ocean in spring and fall at ages between two to four years and move between non-lake and lake-stream systems, often in search of lakes to overwinter (Armstrong 1974). Once mature, Dolly Varden from non-lake populations will migrate back to their natal streams to spawn. In general, movement into lakes are made by immature individuals, individuals that spawned in other streams, and individuals ready to spawn in tributaries to the lake (Logan 1962; Marriott 1965; Blackett 1968). Usually, movement into lakes by anadromous Dolly Varden is for overwintering (DeLacy and Morton 1942; Nelson 1959; Logan 1962; Revet 1962; Meehan 1966; Marriott 1967). However, overwintering in large rivers also occurs (Armstrong 1974).

Table 70: Summary of stream habitat and life history characteristics of anadromous Dolly Varden.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S/L	S/L/O	O/L/S
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	large gravel	gravel	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	-	riffle, run	riffle, run, pool	-
Velocity Range	moderate	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	8°C	-	-	-
Dominant Prey	-	-	-	-
Duration	September-November	-	3-4 years	-
Size Range	-	-	-	-
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	-

LAKE TROUT (*Salvelinus namaycush*)

Lake trout are endemic to North America (McPhail and Lindsey 1970). They are found from Bristol Bay, Alaska, through the Yukon River drainage and Mackenzie River drainage, across Canada to watersheds draining into the Hudson Bay, the Great Lakes, St. Lawrence River to Labrador (Scott and Crossman 1973). In BC, lake trout are present in the upper Fraser, Peace, and Liard river drainages in the interior and coastal drainages from the Skeena River north into Yukon (McPhail and Lindsey 1970; Scott and Crossman 1973). Lake trout are absent from the Porcupine River drainage in Yukon (Scott and Crossman

1973). Typically, lake trout inhabit large, deep, clear, cold lakes (Rawson 1951; Loftus 1957; Dryer 1966; Johnson et al. 1977; Martin and Oliver 1980), where they are limnetic (Levy et al. 1991).

Spawning takes place between July and November in Ontario (Martin 1956; Loftus 1957) (Table 70), and roughly the same period across Canada (Scott and Crossman 1973). Spawning possibly takes place during October in BC (Ford et al. 1995). There are stream spawning populations in Lake Superior that mature at smaller sizes and spawn over large boulders and coarse gravel in eddies (Loftus 1957) (Appendix 68). Otherwise, spawning and the whole life cycle of lake trout occurs within lakes (McPhail and Lindsey 1970; Scott and Crossman 1973; Ford et al. 1995). Depth of spawning is dependent on lake size (Martin 1956). Lake trout primarily spawn over course substrate such as rubble and gravel (Martin 1956; Ford et al. 1995), and sometimes sand (Thibodeau and Kelso 1990), but never mud or detritus (Martin 1956). Usually, the male will clear mud and sand from the spawning area before spawning takes place, although he does not build a nest (McPhail and Lindsey 1970). Mature females usually do not spawn in successive years (McPhail and Lindsey 1970). Spawning takes place at night at 10-12.8°C (Martin 1956), where eggs are scattered over the substrate (McPhail and Lindsey 1970; Scott and Crossman 1973). Eggs incubate between 15-21 weeks at 0.3-1.0°C (Martin 1956).

Once the young-of-the-year emerge (February to June), they remain on the spawning grounds from a few weeks to a few months feeding on invertebrates (Scott and Crossman 1973; Ford et al. 1995). McPhail and Lindsey (1970) stated that young lake trout remain in shallow water for several years before moving into deeper water. In some Ontario lakes, Martin (1956) reported young-of-the-year leaving the spawning grounds by mid-May. Young-of-the-year and juvenile lake trout move into deeper water, where they switch to feeding primarily on fish (Ford et al. 1995). Adult lake trout are piscivorous and usually the top predator where they exist (Martin and Olver 1980). Lake trout feed on invertebrates and vertebrates, along with plant material (Scott and Crossman 1973; Martin and Olver 1980).

Lake trout mature between the ages of five to eleven years in Great Slave Lake, NWT (Kennedy 1954), and ages seven to eight in Lake Superior (Loftus 1957). Average life span is estimated to be between 25 - 30 years (Scott and Crossman 1973; Ford et al. 1995). Lake trout hybridize with brook trout (Martin and Baldwin 1960).

Table 71: Summary of stream habitat and life history characteristics of lake trout.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L/S	L	L	L
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	gravel, boulder	-	-	-
Dominant Cover	eddies	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	10-12.8°C	-	-	-
Dominant Prey	-	invertebrates	invertebrates, fish	invertebrates, fish
Duration	July-November	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	5-8 years	-
Maximum Age	-	-	-	30 years

INCONNU (*Stenodus leucichthys*)

Inconnu occur from the Kuskokwin River in the Bering Sea, Alaska to the Anderson River near Cape Bathurst in the NWT (Scott and Crossman 1973). Inconnu are found in parts of the Yukon River, Mackenzie River and into the Slave River, south to Fort Smith and Fort Nelson in the Liard River drainage. Inconnu are found across the Arctic drainages of northern Asia to the White Sea. Distribution of inconnu in BC is limited to Teslin Lake in the Yukon River drainage and Muskwa River in the Liard River drainage (McPhail and Carveth 1993a). Inconnu are Blue listed in BC (CDC 2001).

Inconnu are primarily anadromous (along coastal regions) (Scott and Crossman 1973), but freshwater resident populations occur in the Upper Yukon River and several locations in Alaska (ADFG 2002). Otolith analysis of inconnu from different locations in the Mackenzie River drainage determined that inconnu from the Slave River are exclusively freshwater resident, while inconnu from the Arctic Red River remain in freshwater for one to two years before migrating to saltwater (Howland et al. 2001). Both anadromous and lake resident populations are migratory (McPhail and Lindsey 1970). Inconnu have been recorded migrating up to 1,600 km in the Yukon River drainage (Alt 1977). Work conducted in Great Slave Lake, NWT suggests that inconnu move upstream into tributary rivers to spawn and move back downstream after spawning (Scott and Crossman 1973). Specifically in the Slave River, inconnu migrate to mid-river in mid-summer to spawn and then by the end of October, inconnu migrate back downstream to Great Slave Lake (Tallman 1996). In the Yukon and Kuskokwim rivers, inconnu quickly migrate downstream after spawning to overwintering areas in the lower reaches (Alt 1977). In other systems, inconnu will overwinter in slightly brackish inlets. The upstream pre-spawning migration is much slower than the post-spawning migration, as inconnu begin this migration before ice break-up. In the Slave River, inconnu move into streams starting in August at water temperatures of 19-20°C (Tallman et al. 1996 from Tallman 1996). Non-spawning individuals migrate to feeding areas, while spawning individuals move to spawning areas where they spawn during the summer and fall (Alt 1977). Young inconnu may remain up to two years in the stream environment before migrating back to the lake (Scott and Crossman 1973) (Table 71).

Spawning takes place between August and October (Scott and Crossman 1973; Tallman 1996)) during the late afternoon and evening in water ≤ 4.5°C (ADFG 2002). Spawning takes place in fast flowing water over gravel substrates at depths between roughly 1.2-2.5 m (Appendix 69). It is thought that inconnu have site fidelity and return to their natal stream to spawn (Tallman 1996). Males and females emit their gametes within the water column, and the semi-adhesive eggs settle into the substrate. Adults can spawn several times in their lifetime. Eggs take up to six months to develop and hatch. Once emerged, young-of-the-year migrate downstream to rearing in large rivers where they feed on plankton. In the Slave River, larval young-of the-year inconnu were caught in drift samples in the lower reach of the river in mid-May (Tallman 1996). Juvenile inconnu feed on insects and crustaceans, and adults feed on fish (Scott and Crossman 1973).

Inconnu in Great Slave Lake sexually mature between seven to ten years of age and live up to 11 years (Scott and Crossman 1973). Alt (1973) found that females from the lower Yukon, Kuskokwim and Kobuk rivers matured between the ages of five and nine, while males matured between ages seven and 12. Male inconnu from the Slave River, NWT were found to mature at age five (Tallman 1996). Maximum age in Alaska populations range from nine to 20 years (Alt 1973). In comparison, individuals from Siberian populations can live up to 21 years (Scott and Crossman 1973). Size range of adults is 457-762 mm, however a specimen 1500 mm in length has been recorded.

Table 72: Summary of stream habitat and life history characteristics of inconnu.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S/L	O/L
Stream Gradient	-	-	-	-
Depth Range	1.2-2.5 m	-	-	-
Dominant Substrate	gravel	-	-	-
Dominant Cover	none	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	fast	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	<4.5°C	-	-	-
Dominant Prey	-	plankton	invertebrates, crustaceans	fish
Duration	August-October	-	2 years	-
Size Range	-	-	-	457-762, maximum: 1500 mm
Age of Maturity	-	-	females: 5-9 years, males: 7-12 years	-
Maximum Age	-	-	-	20 years

ARCTIC GRAYLING (*Thymallus arcticus*)

Arctic grayling have a holarctic distribution and are found from Hudson Bay to Alaska and the Bering Sea to the Ob River to northern Mongolia and the Upper Yalu River (Scott and Crossman 1973). In Yukon and BC, Arctic grayling are found in the Mackenzie, Yukon, Alsek and Taku river drainages, and in BC in the Stikine River drainage (Haas 1998). They occur primarily in the headwaters and upstream of major barriers (Haas 1998). They have been introduced to various locations in the United States, Alberta, and Saskatchewan (Scott and Crossman 1973; Haas 1998). Arctic grayling in the Belly River, Alberta and the Flathead River, BC were established from the natural expansion of introduced populations in Montana (Scott and Crossman 1973; Haas 1998). Many populations of Arctic grayling are in decline or have gone extinct throughout BC and other areas of their range, including the population from the Flathead River (Haas 1998). Habitat degradation and overfishing are thought to be the main causes of the decline (Northcote 1995). The population of Arctic grayling residing above the W.A.C. Bennett Dam in the Williston Reservoir system, BC is Red listed because of a large decline in population density over the past 20 years (Cannings and Ptolemy 1998; CDC 2001). They seem to be highly adapted to local environmental conditions, so perturbations made by humans can be especially detrimental (McPhail and Lindsey 1970).

Arctic grayling typically inhabit clear water of large cold rivers, and smaller, rocky tributary streams, and lakes (Scott and Crossman 1973; Northcote 1993) (Table 72). They avoid turbid waters, but will inhabit milky, glacial streams (Ford et al. 1995). All life stages migrate between summer and overwinter habitats. Generally, adult Arctic grayling inhabit mainstem reaches during the fall and winter months, and they move into tributary streams to spawn (Northcote 1993). Adults were found to use mainstem pools, riffles, runs and side- and back-channel habitats in the summer and fall in the Sukunka River drainage (Stuart and Chislett 1979) (Appendix 70). In pools, they can be associated with small boulders and gravel (Schmidt and O'Brien 1982), or bedrock and boulders (Stuart and Chislett 1979). In the fall young-of-the-year Arctic grayling move upstream, and in the spring when runoff peaks near 16.8 m^3/s, they move downstream (Stuart and Chislett 1979). In general, juveniles move upstream in September-November, and downstream in the summer between June and August in the Sukunka River drainage.

Spawning occurs immediately after ice break-up in small tributary streams of large rivers (Scott and Crossman 1973) and lakes (Clark 1994). In BC, this happens between mid-May and mid-June (Ford et al. 1995), and elsewhere between April and June when temperatures are between 7 - 10°C (Scott and Crossman 1973; Craig and Poulin 1975; Beauchamp 1990). Spawning takes place over gravel and rock

in small tributary streams, but when no appropriate spawning habitat is available, spawning occurs over gravel and rock or sometimes over muddy vegetated areas in pools of large rivers (Scott and Crossman 1973) (Appendix 70). Males are territorial and require visual isolation from other males (Northcote 1993), however no redd or nest is made during spawning. Adults return to large rivers or lakes after spawning and provide no parental care for the eggs. Eggs hatch relatively quickly (eight to 32 days) depending on water temperature during incubation (15.5 - 5.8°C, Kratt and Smith 1977; Krueger 1981; Kaya 1989), and young-of-the-year grow rapidly during their first year of life (Harper 1948; Kratt and Smith 1979; Liknes and Gould 1987; Kindschi and Barrows 1990).

Young-of-the-year inhabit side-channel pools and riffles (Stuart and Chislett 1979). Newly emerged fry in the Sukunka River drainage moved into shallow side-channel pools and back-channels where water temperatures ranged from 11-14°C (Stuart and Chislett 1979). In these habitats, young-of-the-year Arctic grayling were associated with sand, gravel, cobble, boulder, and silt substrates (Stuart and Chislett 1979; Ford et al. 1995), although in the Swan River drainage in Alberta, young-of-the-year were found in areas with very little silt, but with rubble and gravel as the dominant substrates (Lucko 1992). Young-of-the-year were found in shallow water (0-60 cm) in all habitat types at all times of year (except for winter when they were not found) in the Sukunka River drainage (Stuart and Chislett 1979).

Juvenile Arctic grayling usually stay within the nursery tributary streams during summer and may overwinter in lakes with adults (Ford et al. 1995), however in Fielding Lake, Alaska, juvenile Arctic grayling were caught along the beach during June (Clark 1994). Young juveniles were found in pool, riffle and run habitat of the mainstem and side-channel, while older juveniles were found almost exclusively in pool habitat (Stuart and Chislett 1979). Older juveniles were less frequently found in runs and riffles, usually with velocities ≤ 0.8 m/s. Arctic grayling inhabit deeper water as they get older, as young-of-the-year individuals were found in water 0-25 cm deep, and age three year old individuals were found in pools > 2 m deep. Arctic grayling in tributaries form territories, with the larger fish inhabiting the optimal locations (Craig and Poulin 1975; Kratt and Smith 1979; Stuart and Chislett 1979). Decreasing temperatures trigger movement downstream to overwintering areas in main stem rivers or lakes (Ford et al. 1995). In rivers, adults can be found in water < 30 cm and velocities 0.21 - 0.8 m/s (Hubert et al. 1985; Liknes and Gould 1987; Ford et al. 1995).

Age of sexual maturity varies slightly from south to north (Ford et al. 1995). In Yukon and NWT, sexual maturity is at seven to nine years, while in northern BC, sexual maturity is reached between ages three to six (Rawson 1951; Bishop 1971; Scott and Crossman 1973; Hubert et al. 1985; Liknes and Gould 1987; Northcote 1995). After maturity, spawning may occur each year (Scott and Crossman 1973). Maximum age is reached near 11 - 12 years, and maximum size reached is 757 mm. Adults range in length from 305-381 mm. Arctic grayling prey on plankton (Schmidt and O'Brien 1982) and insects (Scott and Crossman 1973).

Table 73: Summary of stream habitat and life history characteristics of Arctic grayling.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S/L	S/L
Stream Gradient	-	-	-	-
Depth Range	-	0-0.6 m	>0.6 m	- 0.3 m
Dominant Substrate	mud, gravel-rock	silt-boulder	-	gravel, boulder-bedrock
Dominant Cover	-	-	-	-
Dominant Habitat	pool	side and back channel	pool-run	pool-run, backwater
Velocity Range	-	-	<0.8 m/s	0.21-0.8 m/s
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	7-10°C	11-14°C	-	-
Dominant Prey	-	plankton	plankton	plankton
Duration	April-July	-	-	-
Size Range	-	-	-	305-381 mm, maximum: 757 mm
Age of Maturity	-	-	3-9 years	-
Maximum Age	-	-	-	12 years

TROUT-PERCHES (*PERCOPSIDAE*)

TROUT-PERCH (*Percopsis omiscomaycus*)

The range of trout-perch extends from northern BC, to the Mackenzie River delta at Aklavik, NWT, (McAllister 1961), west along coastal Alaska, then east to the Hudson River and south to the Mississippi Valley (Lindsey 1956). They are present in the Porcupine River and the lower portion of the Yukon River (Scott and Crossman 1973). In BC, trout-perch are limited to the Liard and Peace river drainages (Lindsey 1956).

Trout-perch are lake dwelling, but can also be found in turbid rivers and small, boggy tributaries throughout its range (Dymond and Scott 1941; Scott and Crossman 1973) and are often found in shallow areas of muddy flowing water in the northern extent of their range (Lindsey 1956; McAllister 1961; Scott and Crossman 1973) (Table 73; Appendix 71). Typically, trout-perch inhabit deep waters of lakes during the day and shallower waters at night (Emery 1973; Scott and Crossman 1973; Morrow 1980). In streams, trout-perch hide in long, deep pools under undercut banks, roots and woody debris during the day, and move to shallower water at night to feed (Morrow 1980).

Spawning takes place between late-May and mid-August depending on location (Lawler 1954; Magnuson and Smith 1963; McPhail and Lindsey 1970; Scott and Crossman 1973). Spawning typically takes place in streams, although there are some reports of spawning on lake shores (Langlois 1954; Magnuson and Smith 1963; Scott and Crossman 1973; Morrow 1980). In streams, trout-perch spawn over rocky substrate in shallow areas of small streams (Lawler 1954; Scott and Crossman 1973). Eggs hatch within 20 days (Lawler 1954). Three weeks after hatching, young-of-the-year trout-perch move into deeper water (Magnuson and Smith 1963). Kinney (1950) reported trout-perch spawning at age one, although others have concluded sexual maturity is not until age two for males and age three for females (Lawler 1954; Magnuson and Smith 1963; Morrow 1980). Spawning populations consist of a mixture of one, two, three and four years olds, because a small percentage of individuals spawn twice (Kinney 1950; Lawler 1954; Magnuson and Smith 1963). Females are larger than males, and live to age four, while males live to age three (Trautman 1957; Priegel 1962; Magnuson and Smith 1963).

Table 74: Summary of stream habitat and life history characteristics of trout-perch.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S/L	L/S	L/S
Stream Gradient	-	-	-	-
Depth Range	shallow	-	-	shallow-deep
Dominant Substrate	rocky	-	-	mud
Dominant Cover	-	-	-	woody debris, undercut banks
Dominant Habitat	-	-	-	pool
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	turbid
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	-	-
Duration	May-August	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	1-3 years	-
Maximum Age	-	-	-	female: 3 years, male: 4 years

CODS (*GADIDAE*)

BURBOT (*Lota lota*)

Burbot are unique as they are the only freshwater cod species (Scott and Crossman 1973). Burbot occur in lakes and large rivers throughout BC and Yukon, except along the BC coast and islands (Scott and Crossman 1973; Ford et al. 1995). Burbot are distributed across northern Eurasia and North America (McPhail and Lindsey 1970). In Canada and the United States, burbot are found from the Columbia River north to the Bering Sea and the Arctic Ocean, east to Labrador and south again to Missouri (McPhail and Lindsey 1970). Burbot populations from the lower Kootenay River and lower Columbia River in BC are Red listed (CDC 2001).

Burbot typically inhabit deep waters of lakes (Rawson 1951; Dryer 1966), but they also inhabit cool, large rivers (Scott and Crossman 1973; Tallman 1996). In lakes, burbot seek deeper cooler waters during the summer (Scott and Crossman 1973), but move into shallower water in the fall and winter (Lawler 1963; Scott and Crossman 1973; Bruce 1974; Morrow 1980; Kirillov 1988a; 1988b; Carl 1992; Edsall et al. 1993; Ford et al. 1995). In streams, burbot habitat use is less understood. Porter et al. (2000) caught juvenile burbot in streams with an average bank-full width of 25.5 m, average maximum summer temperature of 20.6°C, and an average watershed gradient of 0.9% (Table 74). Adult burbot from the Tanana River, Alaska were caught in traps set 1.0-1.5 m deep near the shore (Breeser et al. 1988) (Appendix 72).

Burbot are one of the few freshwater species to spawn during midwinter (McPhail and Lindsey 1970), often under ice (Sorokin 1971; Ford et al. 1995). Burbot are largely sedentary until spawning (Tallman 1996). Spawning migrations start in February in the Slave River, NWT (Tallman 1996) and in general spawning occurs when temperatures range between 0.6-1.7°C between January and March (Scott and Crossman 1973). Burbot spawn in shallow areas of either lakes (Mansfield et al. 1983; Ghan and Sprules 1991) or rivers (McPhail and Lindsey 1970; Sorokin 1971; Arndt and Hutchinson 2000). In rivers they spawn over clean sand, gravel or cobble and rubble substrate (Scott and Crossman 1973; Bruce 1974; Morrow 1980; Breeser et al. 1988; Ford et al. 1995), although eggs laying on leafy detritus has been observed (Sorokin 1971). In lakes, burbot spawn over clear areas with limited silt and detritus accumulation, in water typically 0.3 - 3.0 m deep (McCrimmon and Devitt 1954; McPhail and Lindsey 1970; Sorokin 1971; Scott and Crossman 1973; Morrow 1980; Mansfield et al. 1983; Ford et al. 1995), yet spawning in deeper water has been observed (Scott and Crossman 1973). Spawning activity

commences during late-January (Hewson 1955) and continues to March (McCrimmon and Devitt 1954; Lawler 1963; Faber 1970; Scott and Crossman 1973; Morrow 1980; Breeser et al. 1988; Ford et al. 1995). The semi-buoyant eggs are broadcast into the water column just above the substrate and after a few days become demersal and settle into the interstices of the substrate (Sorokin 1971; Morrow 1980; Ford et al. 1995). Optimal egg incubation temperature ranges between 2 - 6°C (Taylor 2001). Egg survival was found to be highest at 3°C, and lowest (all eggs died) at temperatures > 6°C. In the laboratory, Taylor (2001) found that eggs hatched within 28 days at 5°C, and 38 days at 3°C, while Scott and Crossman (1973) reported hatching after 30 days at about 12°C.

Once eggs hatch in the river, larvae enter the drift (Tallman 1996). In the Slave River, larval young-of the-year burbot were caught in drift samples in the lower reach of the river in early-June (Tallman 1996). Larvae are limnetic (Clady 1976; Mansfield et al. 1983; Ghan and Sprules 1991; Ryder and Pesendorfer 1992), but by early summer, at a size range of 21 - 50 mm, larvae shift to a primarily benthic form (Ryder and Pesendorfer 1992; McPhail 1997a). In streams, young burbot associate with undercut banks, submerged logs and weeds preferably near rocky areas, but will use sandy areas (Scott and Crossman 1973; Hanson and Qadri 1980). Juvenile burbot were found in the Nazko River, BC, in shallow, fast flowing water over gravel and cobble substrates (Porter and Rosenfeld 1999).

Juvenile burbot feed on benthic invertebrates, and fish (McPhail and Paragamian 2000). Adult burbot are mainly piscivorous (McCrimmon and Devitt 1954; Lawler 1963; Bruce 1974; Parsons 1975; Ryan 1980), but are known to eat benthic invertebrates during the summer and fall (Lawler 1963; Bailey 1972; Ryan 1980). Sexual maturity of burbot may be delayed in colder water (Hewson 1955). There is debate over the timing of sexual maturity between males and females. Female burbot may mature at an earlier age (two years) and smaller size then males (Hewson 1955), yet males are known to spawn a year before females (from McPhail and Paragamian 2000). Typically across their range, burbot reach sexually maturity between two to eight years (McCrimmon and Devitt 1954; Scott and Crossman 1973; Ryan 1980; Ford et al. 1995; Tallman 1996). Maximum age in northern waters is recorded at 22 years, but life span is shorter in more southern populations (from McPhail and Paragamian 2000). Adults aged 8-20 range in size from 350-937 mm from the Great Slave Lake system, NWT (Tallman 1996).

Table 75: Summary of stream habitat and life history characteristics of burbot.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L/S	L/S	L/S 25.5 m	L/S
Stream Gradient	-	-	0.9%	-
Depth Range	-	-	-	-
Dominant Substrate	sand-boulder	sand-rocky	sand-cobble	-
Dominant Cover	substrate	weeds, undercut banks, logs	weeds, woody debris, undercut banks	-
Dominant Habitat	pool	-	-	-
Velocity Range	-	-	fast	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	0.6-1.7°C	-	-	-
Dominant Prey	-	aquatic invertebrates	macroinvertebrates, fish	fish
Duration	January-March	-	-	-
Size Range	-	-	-	350-937 mm
Age of Maturity	-	-	2-8 years	-
Maximum Age	-	-	-	22 years

STICKLEBACKS (*GASTEROSTEIDAE*)

BROOK STICKLEBACK (*Culaea inconstans*)

The brook stickleback range extends across the northern portion of the continent from Nova Scotia and New York west to the Hay River region of the Great Slave Lake, and south to Montana. In BC, brook stickleback are found only in the Peace River area along the border between Alberta and BC (Scott and Crossman 1973).

Brook stickleback inhabit clear, cold waters in small streams, spring-fed ponds, and swampy areas and stagnant waters of larger lakes (Scott and Crossman 1973). They are often associated with densely vegetated areas, and also have a tolerance for saline waters (Miller and Thomas 1957; Nelson 1968a, Scott and Crossman 1973) (Appendix 73).

Brook stickleback spawn during late-April to July, depending on temperature (Jacobs 1948; Winn 1960; Scott and Crossman 1973) (Table 75). Spawning habitat in streams has not been described. In lakes, spawning occurs when water temperatures reach between 8 - 19°C (Jacobs 1948; Winn 1960). Males build a nest, often on reed stems or grasses, close to the bottom near the substrate in shallow water (Winn 1960; Thomas 1962) of lakes. The nest is made of dead organic matter and algae that is bound together by kidney secretions (Winn 1960; Thomas 1962). More than one female will lay eggs in a single nest (Winn 1960; Thomas 1962). Eggs hatch within eight to nine days at 18.3°C (Breder and Rosen 1966). Males defend the nest until the young leave (Scott and Crossman 1973). There may be some migration between lake and stream habitats (Winn 1960; Lamsa 1963). Brook stickleback feed on fish eggs and aquatic invertebrates (Scott and Crossman 1973). They can reach up to 87 mm in length.

Table 76: Summary of stream habitat and life history characteristics of brook stickleback.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L/S	L/S	L/S	L/S
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	-	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	clear
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	-	invertebrates, fish eggs
Duration	April-July	-	-	-
Size Range	-	-	-	maximum: 87 mm
Age of Maturity	-	-	1 year	-
Maximum Age	-	-	-	-

THREESPINE STICKLEBACK (*Gasterosteus aculeatus*)

Threespine stickleback have a very large distribution that extends along the Pacific coast of North America and Asia, in many parts of Europe, southern Greenland, and the coastal waters from Baffin Island, Hudson Bay to Chesapeake Bay (Scott and Crossman 1973). Threespine stickleback are highly adaptive, and are found in several forms (anadromous, freshwater resident, giant, limnetic/benthic,) across their range and particularly in BC (Schluter and McPhail 1992). In BC, they are found on all the coastal islands, in small streams and rivers along the coast and in the Fraser River to Kawkawa Lake near Hope. The anadromous form inhabits streams, while the other forms do not or are not known to inhabit streams.

Anadromous

Anadromous threespine stickleback differ from freshwater resident populations in that they have a slightly different morphology (more plated, Morrow 1980), they can spawn in saline or freshwater (McPhail 1969), they spawn in areas dense with vegetation, and they reach sexual maturity after one year (Narver 1969) (Table 76; Appendix 74). Young-of-the-year anadromous threespine stickleback leave their natal stream or estuary and move into salt water, often staying near shore within seaweed beds until fall when they move farther from shore (Morrow 1980). Some anadromous individuals were found in the ocean near the surface pelagic zone 800 km from shore (Clemens and Wilby 1961; McPhail and Lindsey 1970).

Table 77: Summary of stream habitat and life history characteristics of anadromous threespine stickleback.

	Spawning	YOY	Adult
Stream/Ocean/Lake	S	O	O
Stream Gradient	-	-	-
Depth Range	-	-	-
Dominant Substrate	-	-	-
Dominant Cover	vegetation	-	-
Dominant Habitat	-	-	-
Velocity Range	-	-	-
Turbidity Range	-	-	-
Oxygen Range	-	-	-
Optimal Temp. Range	-	-	-
Dominant Prey	-	-	-
Duration	-	-	-
Size Range	-	-	-
Age of Maturity	-	1 year	-
Maximum Age	-	-	-

Freshwater Resident

In general, freshwater resident threespine stickleback are found in shallow bays of lakes (Brett and Pritchard 1946b, Jakobsen et al. 1988), or slow streams (McPhail and Lindsey 1970). Threespine stickleback were abundant in the limnetic zone of lakes in BC (Simpson et al. 1981). They associate with vegetation (Brett and Pritchard 1946b, Jakobsen et al. 1988), but this association is not as strong as with other stickleback species (McPhail and Lindsey 1970).

Giant Black Stickleback

Giant black stickleback differ from 'normal' threespine stickleback as they are larger, black in colour, more streamlined (Moodie and Reimchen 1973) and they are have never been captured in streams (Moodie 1972a, Cannings and Ptolemy 1998). Recent work on the taxonomy of giant black stickleback at the University of British Columbia, shows that the giant black stickleback may be separate from other *Gasterosteus* populations on the west coast of BC (Cannings and Ptolemy 1998). This unique stickleback is thought to have evolved after the last glaciation (Gach and Reimchen 1989). The large size of this stickleback form is thought to be an adaptive response to predation by cutthroat trout and common loons (*Gavia immer*) (Moodie 1972b). Giant black stickleback are found in Drizzle and Mayer lakes on the east side of Graham Island, the northern Queen Charlotte Island, and Misty Lake on northern Vancouver Island (Cannings and Ptolemy 1998). They may also be present in two other lakes on the central, northern mainland coast (Cannings and Ptolemy 1998). All these lakes are low elevation lakes. Giant black stickleback are considered a vulnerable species by COSEWIC, and are Red listed in BC (Cannings and Ptolemy 1998).

Limnetic-Benthic Species Pairs

The two forms of threespine stickleback, the limnetic (plankton feeder), and benthic (benthic invertebrate feeder) exist due to trophic competition and character displacement (McPhail 1992; 1993a) in the lake environment. They are not known to occur in streams or use stream habitat during their life cycle. They are morphologically and ecologically distinct from one another (McPhail 1992). There are five lakes (formerly six) along the coast of BC where the limnetic-benthic threespine stickleback species pairs exist. These include Enos Lake, Vancouver Island, and Paxton, Priest, Balkwill and Emily lakes on Texada Island (Haas 1998). They were present in Hadley Lake on Lasqueti Island, however this population was extirpated after the deliberate introduction of an exotic species. The rest of the species pair populations are Red listed (CDC 2001). It is likely that populations within each lake have independently undergone rapid post-glacial speciation thereby making each species pair unique (distinct from one another) (McPhail 1984; 1992; 1993a; 1994; Schluter 1996; Taylor et al. 1996). Low levels of hybridization occur within each lake, however the distinct phenotypes are maintained (McPhail 1993a).

NINESPINE STICKLEBACK (*Pungitius pungitius*)

The ninespine stickleback has a more north-eastern distribution within Canada, yet is found in all provinces and territories (Scott and Crossman 1973). In Yukon, this species is found in the Mackenzie River drainage (McPhail and Lindsey 1970). In BC ninespine stickleback are Red listed (CDC 2001), as they are found in the north-east corner of the province near Old Fort Nelson in the Fort Nelson River (McPhail and Lindsey 1970; Scott and Crossman 1973; Cannings and Ptolemy 1998), however during two recent surveys in that area, no ninespine stickleback were collected (Haas 1998). They have recently been collected for the first time further south in the Petitot River in that region. Elsewhere, ninespine stickleback inhabit fresh and saline waters along the coast from the Aleutian Islands in Alaska to the Mackenzie River delta (McPhail and Lindsey 1970). Ninespine stickleback are present in the Arctic Archipelago, and inland throughout the NWT, across the prairie provinces to Labrador and Nova Scotia (McPhail and Lindsey 1970; Scott and Crossman 1973). They are not present in southern Alberta and Saskatchewan (Scott and Crossman 1973). This species is also found down the Pacific Coast of Kamchatka and Japan, as well as the Arctic and Baltic drainages (Haas 1998).

Ninespine stickleback inhabit shallow bays in lakes, tundra ponds and slow streams (McPhail and Lindsey 1970) (Table 77). Stream habitat is not well documented for this species. In lakes, ninespine stickleback associate with densely vegetated areas (McPhail and Lindsey 1970; Dadswell 1972), but are also found in open water areas offshore (Nelson 1968b; Dadswell 1972; Emery 1973; Scott and Crossman 1973), and to great depths (Dryer 1966). They also have a fairly high tolerance for saline water (Nelson 1968a). Populations that reside mostly in estuaries will move into streams to spawn (Scott and Crossman 1973). During the summer, estuarine populations are sometimes confined to the lower reaches of rivers (McPhail and Lindsey 1970).

Spawning occurs from May-July (McPhail and Lindsey 1970). During spawning in lakes, males build a nest on the stems of plants, usually off the bottom substrates most often in shallow water (McKenzie and Keenleyside 1970; Reckahn 1970; Scott and Crossman 1973). The nest is made up of fragments of algae and other aquatic vegetation held together by kidney secretions (McKenzie and Keenleyside 1970; McPhail and Lindsey 1970; Reckahn 1970; Scott and Crossman 1973; Wootton 1976; Morrow 1980). Males entices a female to swim through and deposit eggs within the nest (Scott and Crossman 1973). More than one female will deposit eggs in a single nest (Scott and Crossman 1973). Males aerate the eggs within the nest by fanning his pectoral fin over the nest entrance (Scott and Crossman 1973; Wootton 1976; Burgess 1978; Scott and Scott 1988). Males guard the nest until the eggs have hatched and the young are free swimming (Scott and Crossman 1973). In densely vegetated areas, the male will construct an area above the nest, built from nest materials, where the young-of-the-year rest (McPhail and

Lindsey 1970; Wootton 1976; Keenleyside 1979; Morrow 1980). Sexual maturity of lake populations is thought to be within the first year, and life span is about three-and-a-half years (Jones and Hynes 1950). Ninespine stickleback from the St. Lawrence River system may live to just over 1 year (Coad and Power 1973). Individuals from this species have been found to reach five years of age (Wootton 1984). Because sexual maturity is within the first year, there is no real juvenile stage for this species.

Table 78: Summary of stream habitat and life history characteristics of ninespine stickleback.

	Spawning	YOY	Adult
Stream/Ocean/Lake	L/S	L/S	L/S/O
Stream Gradient	-	-	-
Depth Range	-	-	-
Dominant Substrate	-	-	-
Dominant Cover	-	-	-
Dominant Habitat	-	-	-
Velocity Range	-	-	-
Turbidity Range	-	--	-
Oxygen Range	-	-	-
Optimal Temp. Range	-	-	-
Dominant Prey	-	-	fish eggs, benthic invertebrates, molluscs
Duration	May-July	-	-
Size Range	-	-	-
Age of Maturity	-	1 year	-
Maximum Age	-	-	3 years

SCULPINS (*COTTIDAE*)

COASTRANGE SCULPIN (*Cottus aleuticus*)

Coastrange sculpin are widespread in coastal streams on the Pacific coast from San Luis Obispo County, central California, to Kiska Island, Alaska (Scott and Crossman 1973; Lee et al. 1980). In BC, they are known in streams and inland lakes in the Fraser, Skeena, Nass and Stikine river drainages, as well as in small coastal streams and on Vancouver Island and the Queen Charlotte Islands (Scott and Crossman 1973). Although *Cottus* are primarily freshwater, coastrange sculpin can withstand brackish waters (Scott and Crossman 1973; Brown et al. 1995). They have also been found to use estuarine habitat during part of their life cycle in the Eel River, California (Brown et al. 1995). In 1937; Ricker discovered a dwarf form of coastrange sculpin in Cultus Lake, BC called the Cultus pygmy sculpin (*Cottus* sp.) (Ricker 1960). Cultus pygmy sculpin are endemic to Canada, as they are found only in Cultus Lake (Coffie 1998) and are Red listed (CDC 2001). A similar form is found in Lake Washington, Washington state (Lee et al. 1980; McPhail and Lindsey 1986).

Coastrange sculpin spawn during spring from February to mid-June (Scott and Crossman 1973). Coastrange sculpin were observed migrating downstream in the Keogh River, BC during mid-April (Ward et al. 1990). Adhesive eggs are deposited over gravel in riffles of small coastal or tributary streams (Ricker 1960; Scott and Crossman 1973) (Table 78; Appendix 75). Males guard the egg mass and may spawn with more than one female (Scott and Crossman 1973). Larvae are not present until July or August (McLarney 1968). Larvae are planktonic (McLarney 1968), residing within the top 6 m from the surface, for the first 32 and 35 days before taking up benthic living (Heard 1965; Scott and Crossman 1973; Ikusemiju 1975). Once benthic, coastrange sculpin prefer lotic environments (Scott and Crossman 1973).

Coastrange sculpin are often found in sympatry with prickly sculpin (*C. asper*) in coastal streams and rivers from Alaska to southeastern California (Lee et al. 1980). In several small coastal streams on Vancouver Island, sympatric coastrange sculpin inhabit riffles, while prickly sculpin inhabit deeper pools

(Mason and Machidori 1976). In larger rivers both niche partitioning (White and Harvey 1999) and niche overlap (Brown et al. 1995) have been documented. In the Smith River, California, coastrange sculpin inhabit areas < 1 m deep with a velocity > 5 cm/s, while prickly sculpin inhabit deeper, slower water (White and Harvey 1999). Very little habitat segregation was noticed between the two species in the Eel River, California (Brown et al. 1995).

In lakes, coastrange sculpin generally inhabit the benthic zone in deep-water (Ricker 1941), or sandy or muddy nearshore areas (Scott and Crossman 1973) in quiet water near lake shores and tributary mouths (McPhail and Lindsey 1970) and undergo diel vertical migrations (Ikusemiju 1975). Coastrange sculpin feed primarily at night on invertebrates, salmonid eggs and young-of-the-year (Pritchard 1936; Shapovalov and Taft 1954; McPhail and Lindsey 1970; Foote and Brown 1997). Maximum age of coastrange sculpin is estimated to be four years (Scott and Crossman 1973).

Table 79: Summary of stream habitat and life history characteristics of coastrange sculpin.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S/L	S/L	S/L
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	gravel	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	riffle	-	-	riffle
Velocity Range	-	-	-	>0.05 m/s
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	-	invertebrates, fish eggs, fish
Duration	February-June	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	4 years

PRICKLY SCULPIN (*Cottus asper*)

The distribution of prickly sculpin ranges along the Pacific coast of North America from Seward, Alaska, south to Ventura River, California (McPhail and Lindsey 1970; Scott and Crossman 1973). No prickly sculpin are found in Yukon. In BC, prickly sculpin are found in coastal rivers and lakes and in the Nass, Stikine, Skeena, Dean, Fraser and Columbia rivers (Scott and Crossman 1973). They are also found on Vancouver Island and the Queen Charlotte Islands (Scott and Crossman 1973) and they exist in only one location east of the Continental Divide, in the upper Peace River (McPhail and Lindsey 1970). They are often found in sympatry with coastrange sculpin in coastal streams and rivers from Alaska to southeastern California (Lee et al. 1980).

Prickly sculpin inhabit a range of habitats, all of which are characteristic of slow flowing water. Prickly sculpin are most commonly freshwater residents, found in pools of clear coastal streams and rivers, turbid rivers, and lake shores, but some catadromous populations may exist (Northcote 1954; Krejsa 1967a; 1967b; McLarney 1968; McPhail and Lindsey 1970) (Table 79; Appendix 76). Porter et al. (2000) conducted fish and fish habitat surveys in 48 streams in the Blackwater River watershed during the summers of 1996 and 1997. Prickly sculpin were found in 16 of 48 streams with an average bank-full width of 33.9 m, average maximum summer temperature of 21.3°C, and an average watershed gradient of 0.9%. In several small coastal streams on Vancouver Island, sympatric coastrange sculpin (*C. aleuticus*) occupied riffles, while prickly sculpin inhabited deeper pools (Mason and Machidori 1976). In larger systems, such as the Smith River, California, prickly sculpin inhabit areas > 7 m deep with a velocity

≤ 5 cm/s, while coastrange sculpin inhabit shallower, faster water (White and Harvey 1999). No inter-specific habitat segregation was observed in the Eel River, California (Brown et al. 1995). In the Nazko River, BC, prickly sculpin were most often found in shallow, fast flowing water over gravel and cobble substrate (Porter and Rosenfeld 1999). The prickly sculpin is abundant in the nearshore environment in some lakes (Ricker 1941; Patten and Rodman 1969), but are found in deep water in Lake Washington, Washington (Ikusemiju 1975) and undergo diel migrations (Broadway and Moyle 1978).

In BC, spawning occurs from February in the southern portion of the range, to late-July in the northern portion (Krejsa 1967b; Scott and Crossman 1973). Prickly sculpin were observed migrating downstream in the Keogh River, BC during mid-April (Ward et al. 1990). Spawning water temperatures range between 8-13°C (Krejsa 1967b). Males select sites in streams that are slow flowing and have boulders, cobbles and a flat rock bottom (Scott and Crossman 1973). The nests are built on the rough underside of rocks. Males will court up to ten females that lay adhesive eggs in the nest. The males defend the nest once the female has left. Eggs hatch within 15 - 16 days if temperatures are 12°C. Larvae may form schools, but remain planktonic (McLarney 1968) for 30-35 days before transforming into a benthic form (Northcote and Hartman 1959; Broadway and Moyle 1978). Benthic young-of-the-year feed on benthic invertebrates and sometimes fish (Ricker 1952). Upper lethal temperature limit for prickly sculpin is 24°C (Black 1953).

Table 80: Summary of stream habitat and life history characteristics of prickly sculpin.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S/L	S/L	S/L
Stream Gradient	-	-	-	0.9%
Depth Range	-	-	-	<7 m
Dominant Substrate	cobble-bedrock	-	-	gravel-boulder
Dominant Cover	substrate	-	-	pools
Dominant Habitat	-	-	-	pool, fast
Velocity Range	-	-	-	<0.05 m/s
Turbidity Range	-	-	-	turbid-clear
Oxygen Range	-	-	-	-
Optimal Temp. Range	8-13°C	-	-	21.3°C, lethal 24°C
Dominant Prey	-	benthic invertebrates, fish	benthic invertebrates, fish	-
Duration	February-July	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	-

MOTTLED SCULPIN (*Cottus bairdi*)

The mottled sculpin has a discontinuous distribution across Canada and the United States. Within the western range, mottled sculpin are mostly confined to a portion of the Columbia River drainage, including parts of the Similkameen, Kettle, Kootenay, and Flathead rivers, as well as Kootenay and the Arrow Lakes in BC (Cannings and Ptolemy 1998), but are also found in Utah, Montana, Idaho and Washington states (Scott and Crossman 1973). Their widest distribution is in eastern North America where they are located from Georgia and Alabama to Labrador and the Great Lakes. Because of their limited distribution, mottled sculpin are considered a vulnerable species in both BC and Alberta by COSEWIC (Campbell 1998), and a vulnerable species in BC by the CDC (CDC 2001).

Mottled sculpin are benthic (Scott and Crossman 1973). In BC, they are primarily found in small, cool streams, large rivers and their tributaries, and clear warm water muddy bottomed weedy mountain lakes (Cannings and Ptolemy 1998). In the Flathead River, mottled sculpin were found to associate with slow flowing areas that are not heavily sedimented but have stones (Hughes and Peden 1984; Peden and

Hughes 1984b), and in the Columbia River they were found in the main stem (Peden et al. 1989) (Table 80; Appendix 77). They are also common in small tributaries of the Similkameen River drainage (Peden et al. 1989).

Observations of habitat association of mottled sculpin in river systems is limited. Young-of-the-year mottled sculpin were observed in extremely shallow water (5-25 cm) associated with the muddy bottom in the Mad River, Ontario (Scott and Crossman 1973). The majority of habitat information comes from lake habitats. Juvenile mottled sculpin are found in the littoral zone of lakes usually underneath cover structures such as rocks and submerged logs (Lyons 1987). Adult mottled sculpin are found in both shallow (Lyons 1987) and deep water of lakes, associated with substrate cover (Emery 1973). At night in lakes mottled sculpin are more active and present in open areas associated with sand substrate (Emery 1973).

Most of the research on behaviour and spawning of mottled sculpin comes from populations in the eastern portion of their range. Timing of spawning is usually in spring during April or mid-May, but can vary depending on location (Scott and Crossman 1973). Males select the spawning site, which is usually under rocks and logs in the shallow littoral zone of lakes (Savage 1963; Scott and Crossman 1973; Lyons 1987). Females deposit adhesive eggs to the underside of the nest object and leave the males to depend the nest (Scott and Crossman 1973). Age of first spawning was estimated by Koster (1936; from Scott and Crossman 1973) as being at three years of age, but sometimes they mature at age two. Koster suggested that spawning occurs at 10°C and hatching happens approximately a month after spawning, but depends largely on water temperature.

Table 81: Summary of stream habitat and life history characteristics of mottled sculpin.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L	L/S	L/S	L/S
Stream Gradient	-	-	-	-
Depth Range	-	5-25 cm	-	-
Dominant Substrate	-	mud	-	stones
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	slow
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	10°C	-	-	-
Dominant Prey	-	-	-	-
Duration	April-May	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	2-3 years	-
Maximum Age	-	-	-	-

SLIMY SCULPIN (*Cottus congatus*)

Slimy sculpin are better adapted for more northern, sub-Arctic conditions than other sculpin species. For this reason, slimy sculpin are found across northern North America from north-eastern Siberia to Virginia, Labrador and Ungava (Scott and Crossman 1973). They are found throughout Yukon, but within BC, slimy sculpin are absent from most small coastal drainages (Scott and Crossman 1973), the lower sections of the Fraser and Columbia river drainages, and coastal islands (except St. Lawrence Island, McPhail and Lindsey 1970). They are present in the Stikine, Taku, Chilkat, and Alsek rivers.

Like other Cottidae, they are benthic, inhabiting the bottom of cool streams and rivers with sandy or rocky bottoms, and lakes (McPhail and Lindsey 1970; Scott and Crossman 1973). In streams in the Peace River drainage in BC, slimy sculpin were caught regularly in streams dominated by riffle and run habitat,

a low percentage of total cover, and substrate larger than gravel (Hopcraft et al. 1995) (Table 81; Appendix 78). In lakes, slimy sculpin are found at a variety of depths depending on latitude, season, time of day and food availability (McPhail and Lindsey 1970; McDonald et al. 1982; Brandt 1986). Slimy sculpin have been observed to move into shallower water of lakeshores to feed on recently spawned sockeye salmon eggs (Foote and Brown 1998).

Slimy sculpin begin to spawn in May, when temperatures reach between 5 - 10°C (Scott and Crossman 1973; Craig and Wells 1976; Mohr 1984). Slimy sculpin typically spawn in rocky streams in the southern portion of their range, but will spawn over stony shores of lakes in the northern portion (McPhail and Lindsey 1970; Mohr 1984). As documented in lakes, males select the nest, which is usually on the underside of either rocks, ledges, submerged logs, tree roots or other debris (Scott and Crossman 1973; Morrow 1980; Mohr 1984), in water < 1.5 m deep (Morrow 1980; Mohr 1984). Males may court more than one female (Scott and Crossman 1973). The females deposit the adhesive eggs on the underside of the surface (Scott and Crossman 1973) that the males then guard after spawning (McPhail and Lindsey 1970; Morrow 1980).

Slimy sculpin mature at a size of about 7 cm (Craig and Wells 1976; Petrosky and Waters 1975; Van Vliet 1964), or two years of age (Mohr 1984). In northern lakes slimy sculpin can live up to eight years (McDonald et al. 1982).

Table 82: Summary of stream habitat and life history characteristics of slimy sculpin.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	S/L	S/L	S L
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	-	-	-	sand-boulder
Dominant Cover	-	-	-	none
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	5-10°C	-	-	-
Dominant Prey	-	-	-	fish eggs
Duration	-	-	-	-
Size Range	-	-	70 mm	-
Age of Maturity	-	-	2 years	-
Maximum Age	-	-	-	-

SHORTHEAD SCULPIN (*Cottus confusus*)

Shorthead sculpin were recognized as a distinct species in 1968 (Lee et al. 1980). Their range extends along the Pacific coast within the Puget Sound and Columbia River drainage in Montana, Idaho, Oregon and Washington states (Scott and Crossman 1973; Page and Burr 1991). Shorthead sculpins have a very small range within Canada as it is only found in southeastern BC and it is restricted to the Slocan River, the Kettle River below Cascade Falls, and some minor tributaries of the Columbia River below the Keenleyside Dam (Cannings and Ptolemy 1998). There have only been nine occurrences of this species in BC (Cannings and Ptolemy 1998), including one in the Flathead River (Peden and Hughes 1984b). Both COSEWIC and the CDC have listed the shorthead sculpin as a vulnerable species (Campbell 1998; CDC 2001). This species is often found in sympatry with mottled sculpin, however it is normally found farther upstream or in smaller tributaries (Scott and Crossman 1973; Cannings and Ptolemy 1998).

This species mainly inhabits fast riffles of small cold streams (Scott and Crossman 1973; Lee et al. 1980, Peden and Hughes 1984b, Peden et al. 1989). Shorthead sculpin are also found in slow currents, over

coarse substrate, such as rubble and gravel, in areas other than riffles (Peden and Hughes 1981; Cannings and Ptolemy 1998), where they spawn underneath larger rocks and boulders (Lee et al. 1980) (Table 82; Appendix 79).

Individuals reach sexual maturity at two to three years of age depending on location, with spawning happening in early spring (Lee et al. 1980). Individuals can reach up to six years of age (Lee et al. 1980).

Table 83: Summary of stream habitat and life history characteristics of shorthead sculpin.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S	S
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	boulder, large rock	-	-	gravel-rubble
Dominant Cover	substrate	-	-	-
Dominant Habitat	riffle	-	-	riffle
Velocity Range	-	-	-	fast, slow
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	-	-
Duration	-	-		-
Size Range	-	-	-	-
Age of Maturity	-	-	2-4 years	-
Maximum Age	-	-	-	6 years

TORRENT SCUPLIN (*Cottus rhotheus*)

Torrent sculpin have a limited distribution in North America and are only found along the west coast of BC (Scott and Crossman 1973). They are distributed in the Puget Sound drainage (Scott and Crossman 1973), and the Columbia River drainage in Montana, Idaho, Oregon and Washington states (Page and Burr 1991). In BC, they are found in the Similkameen River drainage, the Kettle River, the Columbia River between Kinbasket Lake and the United States border, in Kootenay Lake and upper system, and in a few locations in the North Thompson River drainage (Carl et al. 1967; Scott and Crossman 1973).

Sexual maturity probably occurs by age two, with spawning taking place in late June to August (Northcote 1954). They are most often found in association with rubble and gravel substrates in riffles (Page and Burr 1991) (Table 83; Appendix 80). In lakes, torrent sculpin have been found in the upper littoral zone (Northcote 1954) over rocky substrate (Page and Burr 1991; Taylor 2001).

Table 84: Summary of stream habitat and life history characteristics of torrent sculpin.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	-	-	S/L	S/L
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	-	-	-	gravel, rubble
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	riffle
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	-	-
Duration	June-August	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	2 years	-
Maximum Age	-	-	-	-

SPOONHEAD SCULPIN (*Cottus ricei*)

Spoonhead sculpin are found across North America, from the St. Lawrence River and Great Lakes to the BC-Alberta border and north to Great Slave Lake, NWT, and the lower Mackenzie River drainage (McAllister 1962; Scott and Crossman 1973). Spoonhead sculpin are limited to the north-eastern corner south-eastern corners of BC and Yukon respectively in the Peace and Mackenzie river drainages and again in the north-eastern corner of Yukon in the Mackenzie River drainage (Scott and Crossman 1973). Their abundance within any one location is often low, despite their large range and variable habitat use (McPhail and Lindsey 1970). Their distribution is thought to be related to the location of glacial lakes formed after the Wisconsin glaciation period (Houston 1990).

In the western part of their range, spoonhead sculpin are more common in running water, than lakes (McPhail and Lindsey 1970; Dadswell 1972). Spoonhead sculpin occur in rocky, small, fast streams (Page and Burr 1991) and muddy, turbid rivers (Scott and Crossman 1973) (Table 84; Appendix 81). The life history of spoonhead sculpin is largely unknown. They are relatively small compared to other sculpin species, although individuals as large as 110 mm have been taken from Pemichangan Lake, Quebec (Delisle and van Vliet 1968). Spawning is thought to take place during late summer or early fall (Delisle and van Vliet 1968), however no direct observations of spawning have been recorded.

Table 85: Summary of stream habitat and life history characteristics of spoonhead sculpin.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S	S	S	S/L
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	-	-	-	rocky, mud
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	fast
Turbidity Range	-	-	-	turbid
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	-
Dominant Prey	-	-	-	-
Duration	late summer- early fall	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	-	-
Maximum Age	-	-	-	-

SUNFISHES (*CENTRARCHIDAE*)

PUMPKINSEED (*Lepomis gibbosus*)

Pumpkinseeds have been introduced across the western United States (Scott and Crossman 1973), and into BC as they are present in lakes and streams on Vancouver Island, and the Columbia, Okanagan, and lower Fraser river drainages (BC Fisheries 2002). Their native range extends from New Brunswick, through the Great Lakes to eastern Manitoba, south to Ohio, Missouri, South Dakota and north-western Georgia (Scott and Crossman 1973).

The typical habitat of pumpkinseeds is in shallow, vegetated areas of ponds, small lakes, bays of large lakes, and slow areas of large rivers over a range of substrates (Emery 1973; Scott and Crossman 1973; Brown et al. 2000) (Table 85).

Spawning typically takes place during late spring and early summer (Scott and Crossman 1973). Although in the southern portion of the range, spawning lasts until the end of August. Water temperatures during spawning are around 20°C. Males build nests in water < 1 m deep by clearing away the substrate (rock to clay) until a clean, hard surface is exposed. Nests are built near vegetation, and exposed roots of plants. Males may build more than one nest or reuse the same nest during a single spawning season, and females will lay eggs in more than one nest. The adhesive eggs adhere to the substrate, debris and roots within the nest. Males defend the nest and larvae once they hatch (three days at 28°C) for up to 11 days. The young-of-the-year grow fairly fast within their first summer (Reid 1930; Smith 1952; MacKay 1963), but this largely depends on population size (Scott and Crossman 1973). Sexual maturity is at two years, and maximum age is around nine years (Scott and Crossman 1973). Upper lethal temperature limit is 28 - 30°C (Black 1953).

Table 86: Summary of stream habitat and life history characteristics of pumpkinseed.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L	L	L	L/S
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	-	-	-	various sizes
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	slow
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	-	-	-	lethal: 28-30°C
Dominant Prey	-	-	-	-
Duration	-	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	2 years	-
Maximum Age	-	-	-	9 years

SMALLMOUTH BASS (*Micropterus dolomieu*)

In BC, smallmouth bass have been introduced onto Vancouver Island, and into the Okanagan and Columbia river drainages (BC Fisheries 2002). Their native range is within eastern central North America from the Great Lakes and the St. Lawrence River south to the Ohio, Tennessee and upper Mississippi river drainages (Scott and Crossman 1973). Smallmouth bass are typically found in small, shallow lakes (Emery 1973; Scott and Crossman 1973; Hubert and Lackey 1980; Johnson et al. 1977; Brown et al. 2000) but have been observed in rivers (Walters and Wilson 1996). Their preferred

temperature level is between 20.3 - 21.4°C, with a lethal upper limit of 35°C (Scott and Crossman 1973). Scott and Crossman (1973) remark that movements made by smallmouth bass are to remain within the preferred temperature range.

In general, spawning takes place when water temperatures reach 12.8 - 20°C (Scott and Crossman 1973) (Table 86). Males build a nest in sand, gravel and rock substrates in water 0.6 - 6 m deep in lakes and rivers. Males build the nests near rocks, logs and less commonly dense vegetation. Females will deposit eggs in more than one nest over the spawning period (Appendix 82). Males tend the nest once the female has deposited her eggs (Ridgway and Friesen 1992). Eggs are adhesive and attach to coarse substrate within the nest (Scott and Crossman 1973). Males stay with the nest until the eggs have hatched and the larvae metamorphose into young-of-the-year (Scott and Crossman 1973; Ridgway and Friesen 1992). The process of spawning to the dispersal of young-of-the-year can take between 19 - 45 days (Ridgway and Friesen 1992). Males may abandon the nest at any point during this period. Ridgway and Friesen (1992) found that offspring from larger males that spawned early in the breeding season take longer to develop than offspring from males that spawned late in the season. Growth of smallmouth bass within the first year is usually very rapid (Smith 1942; White 1970; Scott and Crossman 1973). Higher growth rate is associated with warmer water for individuals three to five years of age in Lake Huron, Ontario (Coble 1967).

In rivers, young-of-the-year are thought to be habitat generalists and are found over boulder to silt substrates, associated with submerged vegetation in pool and run habitats (Walters and Wilson 1996). In lakes, young-of-the-year smallmouth bass are found over sand, or silted rocks (Brown et al. 2000). Usually, young-of-the-year smallmouth bass are segregated from larger smallmouth bass (Webster 1954; Walters and Wilson 1996; Brown et al. 2000). Juvenile smallmouth bass from lakes can be found near clean cobble substrates and submerged woody debris (Brown et al. 2000).

Sexual maturity is between ages three to five for males and ages four to six for females (Scott and Crossman 1973). Smallmouth bass spawn each year between the ages of four and 12 years (Scott and Crossman 1973; Ridgway and Friesen 1992). The oldest specimen recorded from Canada was 15 years of age (Scott and Crossman 1973). Smallmouth bass are a known predator of juvenile salmonids (Tabor et al. 1993).

Table 87: Summary of stream habitat and life history characteristics of smallmouth bass.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L/S	L/S	L	L
Stream Gradient	-	-	-	-
Depth Range	0.6-6.0 m	-	-	-
Dominant Substrate	rock	silt-boulder	-	-
Dominant Cover	log, substrate	submerged vegetation	-	-
Dominant Habitat	-	pool, run	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	12.8-20°C	-	-	20.3-21.4 C, lethal 35 C
Dominant Prey	-	-	-	-
Duration	-	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	female: 4-6 years, male: 3-5 years	-
Maximum Age	-	-	-	15years

LARGEMOUTH BASS (*Micropterus salmoides*)

In BC, largemouth bass are present in the south-western corner of the province, including the lower Fraser River drainage, and in the interior in the Okanagan and Columbia river drainages (Scott and Crossman 1973; BC Fisheries 2002). Their native range of largemouth bass is in the lower Great Lakes and central Mississippi River drainage, south to the Gulf coast and Florida up the coast to Virginia (Scott and Crossman 1973). Largemouth bass have been introduced across the United States.

Largemouth bass are found in deep water (> 6 m) in the littoral zone of small, warm lakes, bays of large lakes and rarely large, slow rivers (Jeppson and Platts 1959; Scott and Crossman 1973; Beauchamp et al. 1995). Upper lethal temperature limit is 29°C (Black 1953).

Spawning takes place during late spring to early summer or August, with peak spawning during mid-June (Scott and Crossman 1973) (Table 87). Nest building commences when water temperatures reach at least 15.6°C and spawning begins at 16.7 - 18.3°C. Males build nests over gravel, sand to soft mud substrates near reeds, bulrushes and water lilies, in water < 2 m deep. Males clear the area for the nests, which often consist of exposed roots of emergent plants. Females will lay the demersal, adhesive eggs in more than one nest within the breeding season. Eggs hatch within three to five days and remain in the nest for up to a month. The male guards the nest and the young-of-the-year for all or part of this time. Growth is rapid for young-of-the-year during the first summer (Trautman 1957). Predation and nest deterioration are two major causes for the poor survival rate of eggs and young-of-the-year (Scott and Crossman 1973). Largemouth bass reach sexual maturity by age three to four for males, and age four to five for females. Maximum age is around 15 years.

Table 88: Summary of stream habitat and life history characteristics of largemouth bass.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L	L	L	L
Stream Gradient	-	-	-	-
Depth Range	-	-	-	-
Dominant Substrate	-	-	-	-
Dominant Cover	-	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	-
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	16.7-18.3°C	-	-	lethal: 29°C
Dominant Prey	-	-	-	-
Duration	spring-August	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	female: 4-6 years, male: 3-5	-
Maximum Age	-	-	-	15years

BLACK CRAPPIE (*Pomoxis nigromaculatus*)

The native range of black crappies is within fresh and sometimes brackish water of central and eastern North America from the St. Lawrence River and Quebec, south to Florida, west to Texas, and north again to North Dakota and Ontario (Scott and Crossman 1973). On the west coast, black crappies have been introduced to coastal waters in Oregon and Washington states and south-western BC including the lower Fraser River (Scott and Crossman 1973; BC Fisheries 2002). Recently, black crappies have also been introduced, or have spread into the Okanagan River drainage (BC Fisheries 2002). Black crappies usually inhabit vegetated areas in clear, calm and warm ponds, small lakes or shallow bays of large lakes, and slow large rivers. Black crappies are found over sand and mud substrates.

Very little is known about black crappies biology, especially in Canadian waters. Spawning takes place during late spring and early summer when water temperatures reach 19 - 20°C (Scott and Crossman 1973) (Table 88). Males build a nest in very shallow water (< 1 m deep), by clearing away mud, sand and gravel (Appendix 83). Nests are often built near vegetation or undercut banks. Females deposit eggs in more than one nest within a spawning season. Eggs are demersal and adhesive. Males fan the eggs until they hatch (three to five days), at which time the males will defend the young-of-the-year until they leave the nest. Growth of larvae and young-of-the-year is rapid within the first summer (Beckman 1949; Trautman 1957), but this depends largely on the productivity of the habitat and the population abundance (Scott and Crossman 1973). Sexual maturity occurs by ages two to four, and maximum age is between eight to ten years (Beckman 1949; Scott and Crossman 1973).

Table 89: Summary of stream habitat and life history characteristics of black crappie.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L/S	L	L	L,S
Stream Gradient	-	-	-	-
Depth Range	<0.1 m	-	-	-
Dominant Substrate	-	-	-	mud, sand
Dominant Cover	vegetation, undercut banks	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	slow
Turbidity Range	-	-	-	-
Oxygen Range	-	-	-	-
Optimal Temp. Range	19°-20°C	-	-	-
Dominant Prey	-	-	-	-
Duration	spring-summer	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	2-4 years	-
Maximum Age	-	-	-	10 years

PERCHES (*PERCIDAE*)

YELLOW PERCH (*Perca flavescens*)

Yellow perch are native to Alberta, across North America to Nova Scotia and South Carolina (Scott and Crossman 1973). Yellow perch have been introduced into Washington, Oregon, California, Utah, New Mexico and Texas, and have moved into Florida and Alabama, possibly because they are a highly adaptable species that can utilize a wide range of habitat types. Yellow perch exist in BC due to their expansion from both introduced and native populations outside the province. In southern BC in the Pend d'Oreille, Okanagan and Columbia river watersheds, yellow perch have moved north from introduced populations in Washington State (Scott and Crossman 1973). In the Peace River, yellow perch have expanded from native populations in Alberta (BC Fisheries 2002).

Yellow perch inhabit warm and cool lakes, ponds, and slow-flowing rivers, and in brackish and saline water (McKenzie 1959; Scott and Crossman 1973). They are known to occur in open, shallow water and on the bottom, often in schools (Hergenrader and Hasler 1968; Reckahn 1970; Emery 1973; Scott and Crossman 1973; Lyons 1987; Beauchamp et al. 1995). During the summer schools are dense and small, compared to schools in the winter which are more loosely aggregated (Hergenrader and Hasler 1968). The difference in school size between the seasons is attributed to temperature. They inhabit water 19 - 21°C in temperature (Ferguson 1958) (Table 89). The upper lethal temperature limit is 26.5° in BC (Scott and Crossman 1973) and 26 - 29°C and 33°C in other locations (Black 1953). Yellow perch feed in open water and off the bottom during the morning and evening (Scott and Crossman 1973).

Spawning takes place during the spring between mid-April and May or July when water temperatures reach 6.7 - 12.2°C (Scott and Crossman 1973). Yellow perch move to shallow areas of lakes and into tributary streams to spawn. Spawning takes place in areas with rooted vegetation, submerged brush and sunken logs over sand and gravel substrates (Appendix 84). In lakes, in areas devoid of woody debris or vegetation, yellow perch spawn over cobbles substrates (Robillard and Marsden 2001). A female may mate with more than one male during spawning. The eggs are deposited within a semi-buoyant, gelatinous string or tube that can reach up to 2.1 m in length. The tube of eggs adheres to the vegetation or the bottom, and moves within the water column to increase aeration. Eggs hatch within eight to ten days, or up to 27 days at 8.3°C. After the yolk is absorbed (five days) young-of-the-year grow rapidly (Trautman 1957). Juvenile yellow perch often form schools with minnows (if present) such as spottail shiner, in shallow nearshore habitats (Scott and Crossman 1973). During the spring, adult yellow perch move in and out of deeper water, and up and down in the water column, possibly in response to temperature and food availability (Scott and Crossman 1973, Beauchamp et al. 1995). Yellow perch use vegetation, sunken woody debris and rocks as cover (Emery 1973).

Growth rate is faster in warmer water of the southern portion of the range (Smith 1939; Lawler 1953; Sheri and Power 1969; Scott and Crossman 1973), however individuals live longer in the north (Scott and Crossman 1973). The optimum water temperature for yellow perch is 22°C (Huh et al. 1976). Maximum age on average is between nine to ten years, but older individuals (11+ years) have been caught throughout their range (Scott and Crossman 1973). Females attain a larger size overall. Sexual maturity is at three years for males and four years for females.

Table 90: Summary of stream habitat and life history characteristics of yellow perch.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	L/S	L	L	L/S
Stream Gradient	-	-	-	-
Depth Range	shallow	-	-	shallow
Dominant Substrate	sand, gravel	-	-	-
Dominant Cover	emergent and submergent vegetation, sunken logs	-	-	-
Dominant Habitat	-	-	-	-
Velocity Range	-	-	-	slow
Turbidity Range	-	-	-	low
Oxygen Range	-	-	-	-
Optimal Temp. Range	6.7-12.2°C	-	-	22°C, lethal: 33°C
Dominant Prey	-	invertebrates	invertebrates	invertebrates, fish
Duration	April-July	-	-	-
Size Range	-	-	-	-
Age of Maturity	-	-	female: 4 years, male: 3 years	-
Maximum Age	-	-	-	> 11 years

WALLEYE (*Stizostedion vitreum vitreum*)

The natural distribution of walleye is from the mouth of the Mackenzie River south to northeast BC, and southern Alberta, across and south to Alabama, and north again to New Hampshire and Quebec (Scott and Crossman 1973). Walleye are both introduced and native to BC. Walleye are native to the Liard and Peace river drainages in north-eastern BC (Scott and Crossman 1973). Walleye have been introduced to many western states in the Unites States, and as a result have moved into southern BC through the Columbia River drainage (BC Fisheries 2002).

Walleye are sensitive to bright light, so are common in fairly turbid small and large lakes and reservoirs (Dymond and Scott 1941; Rawson 1951; Scott and Crossman 1973; Johnson et al. 1977; Beamesderfer and Rieman 1991; Jones et al. 1994) (Table 90). They can also be found in rivers, as long as the water is

deep and turbid (Scott and Crossman 1973). They avoid strong currents and adults are primarily found in deep pools year round (Paragamian 1989) (Appendix 85). In clear lakes, walleye either associate with cover structures such as sunken logs, vegetation, boulders and even ice or snow, or settle in deep water to avoid direct sunlight (Scott and Crossman 1973; Johnson et al. 1977).

Spawning takes place in tributary rivers or along lake shores (Scott and Crossman 1973). Timing of spawning varies with latitude. Walleye spawn in early-April in southeastern Ontario, and in late-June or later, after ice break-up, in the northern portion of its range (Ryder 1968; Scott and Crossman 1973). Movement to spawning grounds and prespawning behaviours commence when water temperature reach 1.1°-3.9°C (Scott and Crossman 1973; Pitlo 1989), but spawning does not begin until temperature reach at least 5.6 - 11.1°C (Scott and Crossman 1973). Walleye return to the same river to spawn in successive years (Eschmeyer and Crowe 1955; Rawson 1957; Crowe 1962; Olson and Scidmore 1962; Forney 1963; Ryder 1968). Spawning adults migrate to spawning grounds and may hold in backwaters before spawning (Pitlo 1989). Spawning groups can consist of two to eight individuals, with up to two females within the group (Scott and Crossman 1973). Spawning takes place either in rocky, cobble, gravel dominated areas in rivers below dams and falls (Scott and Crossman 1973; Lubinski 1984; Paragamian 1989), along river margins (Pitlo 1989; DiStefano and Hiebert 2000), or on lake shores over coarse gravel to boulder substrates (Martin 1956; Scott and Crossman 1973). In rivers, preferred water velocity for spawning has been estimated to be between 0.15-0.25 m/s (Stevens 1990; DiStefano and Hiebert 2000), yet spawning has been observed at velocities up to 0.6-1.5 m/s (Paragamian 1989; Pitlo 1989; Siegwarth 1993). At night, the spawning group will rush into shallow areas and emit eggs and sperm into the water (Scott and Crossman 1973). Spawning walleye in rivers have been caught in water 0.6-6.1 m deep (Paragamian 1989; Pitlo 1989). The fertilized eggs fall into the cervices between the substrate (Scott and Crossman 1973). Hatching time of eggs varies. Campbell and Rowes (1980) reported 60 days for eggs to hatch. In general, eggs hatch within 12-18 days, and are free swimming 10 - 15 days after hatching (Scott and Crossman 1973).

Little is known of the riverine habitat requirements for young-of-the-year and juvenile walleye. Young walleye from the Slave River, NWT may remain in the river until maturity, when they move to Great Slave Lake (Tallman 1996). In lakes, young-of-the-year walleye are thought to move offshore, into surface water after hatching (Martin 1956; Houde 1969; Houde and Forney 1970; Scott and Crossman 1973), and return to the littoral zone only after they attain a size of 30-40 mm in length (House and Forney 1970). In May to July, young-of-the-year associate with macrophytes at depths ranging between 2-5 m, because of food availability (Pratt and Fox 2001). By the end of the summer, young-of-the-year walleye move into deeper water and associate with the bottom (Scott and Crossman 1973; Pratt and Fox 2001). Juvenile walleye are common in nearshore areas (Johnson 1977; Jones et al. 1994), although they can be found in deeper water as well (Ryder 1977). Juvenile and adult walleye make daily movements along the shoreline in search of food, and also in response to light and temperature levels (Scott and Crossman 1973). Walleye at depths where water temperatures range from 13-18°C.

Sexual maturity of male walleye is between two to four years, and females between three to six years (Scott and Crossman 1973). In a unexploited population, juvenile growth rate was high compared to exploited populations resulting in sexual maturity at age two and three for males and females respectively (Kocovshy and Carline 2001). Walleye from northern populations will reach 20 years of age, while southern populations die after 10-12 years (Scott and Crossman 1973). The optimum water temperature for walleye is 22°C (Kelso 1972; Huh et al. 1976). Mature males and females from the Valley River, Manitoba ranged in sized from 350-648 mm (Gaboury 1985), and from the Slave River, NWT 413-519 mm (Tripp et al. 1981 from Tallman 1996). Juveniles in the Slave River, NWT range in size from 145.5-385 mm.

Table 91: Summary of stream habitat and life history characteristics of walleye.

	Spawning	YOY	Juvenile	Adult
Stream/Ocean/Lake	S/L	L	L	L/S
Stream Gradient	-	-	-	-
Depth Range	>0.6 m	-	-	0.6-6.1 m
Dominant Substrate	gravel, cobble	-	-	gravel, cobble
Dominant Cover	none, woody debris, substrate	-	-	summer: none, winter: substrate, fall: woody debris
Dominant Habitat	fast riffles	-	-	deep pools
Velocity Range	0.15-1.5 m/s	-	-	slow
Turbidity Range	-	-	turbid	turbid
Oxygen Range	-	-	-	-
Optimal Temp. Range	5.6-11.1°C	-	-	22°C
Dominant Prey	-	-	-	-
Duration	April-June	-	-	-
Size Range	-	<129 mm	145.5-385 mm	350-648 mm
Age of Maturity	-	-	2-4 years	-
Maximum Age	-	-	-	20 years

SUMMARY AND RECOMMENDATIONS

We summarized the riverine habitat associations of 86 species of freshwater fish in BC and the Yukon. Where applicable, lake habitat associations were also included. In general, there is missing, unknown, unresearched or unconfirmed accounts of habitat association for the majority of BC and Yukon freshwater fish. In particular, there is limited information available for most non-game fish species such as minnows, suckers, smelts, ciscos, some sculpin and lamprey species, and goldeye. For many species (e.g. cisco), most of the information presented here comes from populations from eastern Canada, the United States or Asian/European populations.

While habitat associations are often family and species specific, there are some common associations that are apparent from the literature assembled in this report. These associations often are different between the various life history stages. We examined some of the more common associations between habitat categories and life history stages by summarising only those associations that are rated as high or medium (Fig. 2, Table 92).

Cover: YOY fish were associated with most types of cover but the interstitial spaces within the substrate had the most associations. The larger juvenile fish were still associated with substrate cover but other forms were of similar importance. Cover associations for adult fish were most often with submergent and emergent vegetation but there were strong associations with other cover types as well. Spawners had fewer strong associations with cover but vegetation, wood and substrate cover were of importance. Only 2 species (chiselmouth and northern redbelly dace) had any association with aquatic algae.

Depth : Many depth associations were reported in the literature. YOY were most often associated with depths < 60 cm while the juveniles were associated depths <100 cm. Adults were equally associated with all depth categories. Spawners were again mostly associated with depths <60 cm.

Velocity/Habitat: All sexually immature life history stages (YOY, juveniles, and adults) had many strong associations with most low velocity habitat types (<1.0 m/s) including pools, runs, riffles and off channel habitats. Only YOY had strong associations with river margins. Spawners had the most associations with riffle habitats but pools and runs also had strong associations. Only spawners had any reported associations with rapids (> 1.0 m/s).

Substrate: There were only 4 reported associations with bedrock and hardpan/clay for all life history stages. YOY had many associations with all substrates from silt/clay (<0.2 cm) to cobble (17 -25 cm) and slightly fewer associations with muck and boulders. The older life history stages had fewer associations with sand but were commonly associated with gravel, rubble, and cobble. Very few associations with the open water were reported.

This report provides a useful reference for stream habitat requirements of BC and Yukon freshwater fish species, however more research is needed to fill in the gaps that exist. Determining basic distribution within watersheds, or more generally within the province and territory, would be a useful start for some species where there is virtually no information available.

Table 92. Summary of river and stream habitat requirements of all B.C. fish for each life history stage. Data are the total of the associations that were rated as being either nearly always or frequently associated with the particular habitat value, expressed as a percentage of each life stage.

Categories	Values	YOY	Juvenile	Adult	Spawning	All ages
Cover	None	4	5	3	5	5
	Submergents	13	16	22	26	19
	Emergents	16	19	20	21	19
	Algae	4	4	3	3	4
	Wood	16	14	15	21	16
	In situ	9	9	10	3	8
	Substrate	27	18	14	16	18
	Overhead	11	14	10	5	11
	Other	0	2	2	0	1
	Assoc. (N)	45	57	59	38	199
Depth	0-20 cm	31	25	22	25	26
	20-60 cm	32	28	22	29	28
	60-100 cm	18	23	17	18	19
	100-200 cm	13	12	19	16	15
	> 200 cm	7	12	19	12	12
	Assoc. (N)	72	57	63	104	296
Velocity / Habitat	Pool	21	20	27	18	22
	Run	17	22	18	22	20
	Riffle	15	22	29	43	28
	Rapid	0	0	0	7	2
	River Margin	23	11	8	2	10
	Off-channel	23	26	18	8	19
	Assoc. (N)	52	65	66	60	243
Substrate	Bedrock	0	0	1	1	1
	Boulder	9	9	11	9	9
	Cobble	16	21	18	14	17
	Rubble	13	17	17	16	16
	Gravel	15	20	23	38	26
	Sand	14	13	9	14	13
	Silt/Clay	14	9	8	4	8
	Muck (detritus)	11	10	12	4	8
	Hard-pan Clay	0	0	0	1	0
	Pelagic	8	2	2	0	3
	Assoc. (N)	79	82	93	138	392

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Appendices

APPENDIX TABLES

Appendix 1: Stream habitat requirements for river lamprey.

Species:	River lamprey				Morph:	Anadromous only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									[A]Life stages burrow in mud.
Gravel	H				1				
Sand									
Silt/Clay									
Muck (Detritus)		H	H			1	1		
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Scott and Crossman 1973
None									
Submergents									
Emergents									
Algae									
Wood									
In Situ									
Substrate		H[A]	H[A]			1	1		
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 2: Stream habitat requirements for Arctic lamprey.

Species:	Arctic lamprey				Morph:	Anadromous and Potamodromous in Lakes			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble									[A]Life stages burrow in mud.
Rubble									[B]moderate
Gravel	H				1				
Sand									
Silt/Clay									
Muck (Detritus)		H	H			1	1		
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Scott and Crossman 1973
Submergents									
Emergents									
Algae									
Wood									
In Situ									
Substrate		H[A]	H[A]			1	1		
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run	H[B]				1				
Rapid									
River Margin		H				1			
Off-Channel									

Appendix 3: Stream habitat requirements for Western brook lamprey.

Species:	Western brook lamprey				**Morph:**	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble									
Rubble									
Gravel	H				1				
Sand	H				1				
Silt/Clay		H	H			2	2		
Muck (Detritus)		H	H			2	2		
Hard-pan Clay									
Pelagic									**References**
Cover:									1. McIntyre 1969
None									2. Pletcher 1963
Submergents									
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle	H				1				
Run									
Rapid									
River Margin		H	H			2	2		
Off-Channel									

Appendix 4: Stream habitat requirements for Pacific lamprey.

Species:	Pacific lamprey				**Morph:**	Anadromous only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble				*H*[A]				1	[A]rock during pre-spawning freshwater residency
Rubble				*H*[A]				1	
Gravel	H				2				
Sand	H	H	H		2	3	3		
Silt/Clay		H	H			1,3	1,3		
Muck (Detritus)		H	H			3	3		
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Scott and Crossman 1973
Submergents									2. Page and Burr 1991
Emergents									3. Pletcher 1963
Algae									
Wood									
In Situ									
Substrate		H	H	H		1,3	1,3	1	
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle	H				2				
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 5 Stream habitat requirements for green sturgeon.

Species:	Green sturgeon				Morph:	Anadromous only				
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**	
Depth: (cm)									**Legend**	
0-20									H = nearly always associated	
20-60									M = frequently associated	
60-100									L = infrequently associated	
100-200									Nil = not associated	
200+			*H*	H			*L*	L	blank = no information	
Substrate:									*italicized* = based on other information	
Bedrock									grayed = not present in freshwater	
Boulder										
Cobble									**Comments**	
Rubble										
Gravel										
Sand										
Silt/Clay										
Muck (Detritus)										
Hard-pan Clay										
Pelagic										
Cover:									**References**	
None									1. van Eenennaam et al. 2001	
Submergents										
Emergents										
Algae										
Wood										
In Situ										
Substrate										
Overhead										
Other										
Velocity/Habitat:										
Pool										
Riffle										
Run										
Rapid										
River Margin			*H*	H			*L*	L		
Off-Channel			*H*	H			*L*	L		

Appendix 6: Stream habitat requirements for white sturgeon.

Species:	White sturgeon				Morph:	freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60	L	L			2	2			M = frequently associated
60-100	L	L			2	2			L = infrequently associated
100-200	H	H	M		2	2	10		Nil = not associated
200+	H	H	H	H	2,3,8,12	2,3	3,9,10	11	blank = no information
Substrate:									*italicized* = based on other information
Bedrock	M				2,5				grayed = not present in freshwater
Boulder	H	L	L		2,3,5	3	3		**Comments**
Cobble	H	L	M		2,3,5,12	3	3		
Rubble	*H*	*L*	*M*		*2,3,12*	*3*	*3*		
Gravel	H	L	M		2,3,6,12	3	3		
Sand	H	H	H	H	2,3,7,12	3	3	11	
Silt/Clay	M	L	L		2	3	3		
Muck (Detritus)									
Hard-pan Clay		L	L			3	3		
Pelagic									
Cover:									**References**
None									1. Lane 1991
Submergents									2. Perrin et al. 1999
Emergents									3. Parsley et al. 1993
Algae									4. Kohlhorst et al. 1991
Wood									5. RL&L 1996
In Situ									6. Stevens and Miller 1970
Substrate		H	H			3	3		7. McCabe and Tracy 1994
Overhead									8. Galbreath 1985
Other									9. Palmer et al. 1988
Velocity/Habitat:									10. McCabe and McConnell 1988
Pool									11. Paragamian and Kruse 2001
Riffle		H	M			3	3		12. Paragamian et al. 2001
Run	H	H	H		2,3,4,5,7	3	3		
Rapid			L				3		
River Margin									
Off-Channel	H		H	H	2,5		1,11	1,11	

Appendix 7: Stream habitat requirements for goldeye.

Species:	Goldeye				Morph:	freshwater only				
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	*H*[A]				3				H = nearly always associated
20-60	*H*[A]				3				M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+			*H*[B]	*H*[B]			3	3	blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									[A]shallow
Gravel									[B]deep overwintering
Sand									[C]feed at surface
Silt/Clay			*H*	H			1	1,2	[D]high turbidity
Muck (Detritus)									
Hard-pan Clay									
Pelagic			*H*[C]	*H*[C]			3	3	
Cover:									**References**
None									1. McPhail and Lindsey 1970
Submergents									2. Brown and Coon 1994
Emergents									3. Scott and Crossman 1973
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other			*H*[D]	*H*[D]			3	3	
Velocity/Habitat:									
Pool	H				3				
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 8: Stream habitat requirements for American shad.

Species:	American shad				Morph:	anadromous only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60	H	H			5	5			M = frequently associated
60-100	H	H			5	5			L = infrequently associated
100-200	H	H			1,5	5			Nil = not associated
200+	H	H			4,5	5			blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder	H				2,3				**Comments**
Cobble									
Rubble									
Gravel	H				2,3				
Sand	H				2,3				
Silt/Clay	H				2,3				
Muck (Detritus)	H				2,3				
Hard-pan Clay									
Pelagic		H				4			
Cover:									**References**
None									1. Beasley and Hightower 2000
Submergents									2. Leggett 1976
Emergents									3. Morrow 1980
Algae									4. Bradbury et al. 1999
Wood									5. Ross et al. 1993
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool	M	H			5	5			
Riffle	M	H			5	5			
Run	H	M			5	5			
Rapid									
River Margin									
Off-Channel									

Appendix 9: Stream habitat requirements for chiselmouth.

Species:	Chiselmouth				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20		H	H			1,3	1,3		H = nearly always associated
20-60		H	H			1,3	1,3		M = frequently associated
60-100		H	H			1,3	1,3		L = infrequently associated
100-200				H				1,3	Nil = not associated
200+				H				1,3	blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder	H			H	2			1,3	**Comments**
Cobble	H			H	5			1,3	
Rubble	H				5				
Gravel				H				4	
Sand				H				4	
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Rosenfeld et al. 2000b
None									2. Scott and Crossman 1973
Submergents						1,3			3. Rosenfeld et al. 1998
Emergents		H				1,3			4. Page and Burr 1991
Algae		H	//	H			*1,3*	1,3	5. Gray and Dauble 2001
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool				H				4	
Riffle				//				*1*	
Run				H				1,4	
Rapid									
River Margin									
Off-Channel		H	H			1,3	1,3		

Appendix 10: Stream habitat requirements for goldfish.

Species:	Goldfish				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20			*H*[A]	*H*[A]				*1,2*	H = nearly always associated
20-60			*H*[A]	*H*[A]				*1,2*	M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									[A]shallow
Gravel									[B]muddy rivers
Sand									[C]vegetated areas
Silt/Clay									
Muck (Detritus)			*H*[B]	*H*[B]			*1,2*	*1,2*	
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Scott and Crossman 1973
Submergents	H		*H*[C]	*H*[C]	1		*1,2*	*1,2*	2. Page and Burr 1991
Emergents			*H*[C]	*H*[C]			*1,2*	*1,2*	
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel				H				2	

Appendix 11: Stream habitat requirements for lake chub.

Species:	Lake chub				**Morph:**	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	*H*				*1*				H = nearly always associated
20-60	*H*				*1*				M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder	*H*				*1*				**Comments**
Cobble	*H*				*1*				
Rubble	*H*				*1*				
Gravel	H			H	2			3	
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. McPhail and Lindsey 1970
None									2. Morrow 1980
Submergents									3. Hopcraft et al. 1995
Emergents									
Algae									
Wood				M				3	
In Situ				H				3	
Substrate	H								
Overhead				L	1,2			3	
Other									
Velocity/Habitat:									
Pool				H				3	
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 12: Stream habitat requirements for common carp.

Species:	Common carp				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									
0-20	*H*								**Legend**
20-60	*H*				1				H = nearly always associated
60-100					1				M = frequently associated
100-200									L = infrequently associated
200+									Nil = not associated
Substrate:									blank = no information
Bedrock									*italicized* = based on other information
Boulder									grayed = not present in freshwater
Cobble									
Rubble									**Comments**
Gravel									[A]during summer
Sand									during spring
Silt/Clay									
Muck (Detritus)	H								
Hard-pan Clay					2				
Pelagic									
Cover:									
None									
Submergents	H								**References**
Emergents	H				2				1. Gray and Dauble 2001
Algae					1,2				2. Scott and Crossman 1973
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle				H[A]					
Run								1	
Rapid									
River Margin									
Off-Channel	H			H[B]					
					1			1	[B]

Appendix 13: Stream habitat requirements for brassy minnow.

Species:	Brassy minnow				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	*H*				2,3				H = nearly always associated
20-60	*H*								M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble									
Rubble									
Gravel				H				1	
Sand				H				1	
Silt/Clay	M			H	5			1	
Muck (Detritus)				H				1	
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Cannings and Ptolemy 1998
None									2. Dobie et al. 1956
Submergents	H				2,3				3. Becker 1983
Emergents	H				2,3				4. McPhail and Lindsey 1970
Algae									5. Scott and Crossman 1973
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel				H				4	

Appendix 14: Stream habitat requirements for pearl dace.

Species:	Pearl dace				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20	H				1				H = nearly always associated
20-60	H				1				M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble									
Rubble									
Gravel	H				1				
Sand	H				1				
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. McPhail and Lindsey 1970
Submergents									
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 15: Stream habitat requirements for peamouth chub.

Species:	Peamouth chub				**Morph:**	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20			*H*	*H*			*1*	*1*	H = nearly always associated
20-60			H	*H*			*1,3*	*1*	M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble	*H*[A]				2				[A]coarse substrate
Rubble	*H*[A]				2				
Gravel			H				3		
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Gray and Dauble 2001
None									2. Schultz 1935
Submergents									3. Porter and Rosenfeld 1999
Emergents			H				3		
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin			H				1		
Off-Channel			H				3		

Appendix 16: Stream habitat requirements for emerald shiner.

Species:	Emerald shiner				**Morph:**	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble									
Rubble									
Gravel									
Sand									
Silt/Clay									
Muck (Detritus)				H				I	
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Cannings and Ptolemy 1998
None									
Submergents									
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 17: Stream habitat requirements for spottail shiner.

Species:	Spottail shiner				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									
Gravel	H				1				
Sand	H				2				
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Becker 1983
Submergents									2. Peer 1966
Emergents									3. Bryan and Scarnecchia 1992
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle	H				1				
Run									
Rapid									
River Margin		H				3			
Off-Channel									

Appendix 18: Stream habitat requirements for northern redbelly dace.

Species:	Northern redbelly dace				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble									
Rubble									
Gravel									
Sand									
Silt/Clay				H				1	
Muck (Detritus)				H				1	
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Scott and Crossman 1973
Submergents									2. Cooper 1935
Emergents									
Algae	H				2				
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 19: Stream habitat requirements for finescale dace.

Species:	Finescale dace				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									^near vegetation
Gravel									
Sand									
Silt/Clay				H				1	
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Page and Burr 1991
None									
Submergents				H^				1	
Emergents				H^				1	
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool				H				1	
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 20: Stream habitat requirements for fathead minnow.

Species:	Fathead minnow				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble									
Rubble									
Gravel									
Sand									
Silt/Clay									
Muck (Detritus)				H				1	
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. McPhail and Lindsey 1970
Submergents									
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 21: Stream habitat requirements for flathead chub.

Species:	Fathead chub				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									
Gravel									
Sand									
Silt/Clay									
Muck (Detritus)				H				1,2	
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Olund and Cross 1961
None									2. McAllister 1961
Submergents									
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 22: Stream habitat requirements for northern pikeminnow.

Species:	Northern pikeminnow				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	*H*	H	H	H	4	1,2,3	1,2,5	5	H = nearly always associated
20-60	*H*	H	H	H	4	1,2,3	1,2,5	5	M = frequently associated
60-100	*H*	L	H	H	4	1,3	1,5	5	L = infrequently associated
100-200	M		H	H	1		1,5	5	Nil = not associated
200+	H		H	H	1		5	5	blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder	L				1				**Comments**
Cobble	H	L			1,2	2			[A]as larval form
Rubble	H	L			1,2	2			[B]vegetation
Gravel	H	M	M		2,4	2,3	1		
Sand		H	H			1,2,3	1		
Silt/Clay		H				2			
Muck (Detritus)									
Hard-pan Clay									
Pelagic		H[A]				2			
Cover:									**References**
None		H	H			1	1		1. Beamesderfer 1992
Submergents		H[B]				2,3			2. Gadomski et al. 2001
Emergents		H[B]	H			1,2	1		3. Barfoot et al. 1999
Algae		M				3			4. Scott and Crossman 1973
Wood									5. Gray and Dauble 2001
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run	H				1,2				
Rapid									
River Margin		H	H			1,2,3	1,5		
Off-Channel		H	H			1,2	1,5		

Appendix 23: Stream habitat requirements for longnose dace.

Species:	Longnose dace				**Morph:**	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20		H	H	*H*		9	5,6,9	5,6,9	H = nearly always associated
20-60		H	H	*H*		9	5,6,9	5,6,9	M = frequently associated
60-100		H	H	H		9	9	9	L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder			*H*	H	10	11	2,4	2,4,5,6	**Comments**
Cobble	H	H	*H*	H	10	11	2,4,9	2,4,9	[A]aquatic vegetation
Rubble	H	H	*H*	H	10	11	2,4,5	2,4	
Gravel	H	H	H	H		11	2,4	2,4	
Sand		H							
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Mullen and Burtin 1995
None									2. Scott and Crossman 1973
Submergents				H[A]					3. Stuart and Chislett 1979
Emergents				H[A]				8	4. McPhail and Carveth 1993b
Algae									5. Porter and Rosenfeld 1999
Wood									6. Gee and Northcote 1963
In Situ									7. McPhail and Lindsey 1970
Substrate				H				1,2,7	8. Hubert and Rahel 1989
Overhead				H				8	9. Gray and Dauble 2001
Other									10 Bartnik 1970
Velocity/Habitat:									11. Brazo et al. 1978
Pool									
Riffle	H	*H*	H	H	10	6	2,4,5,9	2,3,4,5,6,9, 10	
Run			H				5		
Rapid									
River Margin			H				6		
Off-Channel			H				5		

Appendix 24: Stream habitat requirements for Nooksack dace.

Species:	Nooksack dace				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20		H				1,2			H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble			H	H			1,2	1,2	[A]slow glide
Rubble			H	H			1,2	1,2	
Gravel	H		H	H	1		1,2	1,2	
Sand		H				1,2			
Silt/Clay									
Muck (Detritus)		H				1,2			
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. McPhail 1993b
Submergents									2. Inglis et al. 1994
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead			H	H					
Other							1,2	1,2	
Velocity/Habitat:									
Pool									
Riffle	H		H	H	1		1,2	1,2	
Run		H[A]				1,2			
Rapid									
River Margin									
Off-Channel									

Appendix 25: Stream habitat requirements for leopard dace.

Species:	Leopard dace				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20		H	H	H		3	1,2,3	1,2,3	H = nearly always associated
20-60		H	H	H		3	1,2,3	1,2,3	M = frequently associated
60-100		H	H	H		3	1,2,3	1,2,3	L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble			*H*	H			*1*	1,2	[A]aquatic vegetation
Rubble									[B]fast flow
Gravel				H				2	
Sand			H	H			2	2	
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Gray and Dauble 2001
None									2. Porter and Rosenfeld 1999
Submergents			H^A	H^A			2	2	3. Gee and Northcote 1963
Emergents			H^A	H^A			2	2	
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool		H	H	H		3	2,3	2,3	
Riffle			H^B	H			1	1,2	
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 26: Stream habitat requirements for speckled dace.

Species:	Speckled dace				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20			*H*	H			*4*	1,4	H = nearly always associated
20-60			*H*	H			*4*	1,4	M = frequently associated
60-100				H				1,4	L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder				H				2	
Cobble				H[B]				1,2	**Comments**
Rubble			M[A]	H[B]			2,*4*	1,2,4	[A]smooth stones
Gravel			M				2		[B]rocky
Sand			M	Nil			2	2	[C]moderate current
Silt/Clay									[D]fast flowing
Muck (Detritus)				Nil				2	
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Cannings and Ptolemy 1998
Submergents			M						2. Peden and Hughes 1984a
Emergents			M						3. Moyle 1976
Algae			M	M					4. Gray and Dauble 2001
Wood									
In Situ				M					
Substrate			H	H					
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle	H			H[C]	3			1	
Run			H[C]	H[D]			2,4	2,4	
Rapid									
River Margin									
Off-Channel									

Appendix 27: Stream habitat requirements for Umatilla dace.

Species:	Umatilla dace				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20			H[A]				3,4		H = nearly always associated
20-60			H[A]				3,4		M = frequently associated
60-100									L = infrequently associated
100-200				H				3,4	Nil = not associated
200+				H				3,4	blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder				H				1,3,4	**Comments**
Cobble			H	H			3,4	1	[A]shallow
Rubble									[B]fast flowing
Gravel									
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Peden and Hughes 1984a
None									2. Cannings and Ptolemy 1998
Submergents									3. Peden and Hughes 1989
Emergents									4. Peden and Orchard 1993
Algae									
Wood									
In Situ									
Substrate			H	H			3	3	
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle				H[B]				2	
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 28: Stream habitat requirements for redside shiner.

Species:	Redside shiner				**Morph:**	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	H		H	H	3,4		2	2	H = nearly always associated
20-60			H	H			2	2	M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble									[A]near vegetation
Rubble									
Gravel	H		H	H	3		2	2	
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Gray and Dauble 2001
None									2. Porter and Rosenfeld 1999
Submergents	H[A]			H[A]	5			2	3. Weisel and Newman 1951
Emergents	H[A]			H[A]	5			2	4. Lindsey and Northcote 1963
Algae									5. Carl et al. 1967
Wood				H				2	
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle	H				3,4				
Run				H				2	
Rapid									
River Margin		H				1			
Off-Channel	L		H		1		2		

Appendix 29: Stream habitat requirements for tench.

Species:	Tench				Morph:	Freshwater only			Legend/Comments/References
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									^near vegetation
Gravel									
Sand									
Silt/Clay			*H*	H			*I*	I	
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Scott and Crossman 1973
None			*H*	H^			*I*	I	
Submergents			*H*	H^			*I*	I	
Emergents									
Algae									
Wood									
In Situ Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 30: Stream habitat requirements for longnose sucker.

Species:	Longnose sucker				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	H			H[B]	3			1	H = nearly always associated
20-60	H			H[B]	3			1	M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble	H				3				[B]shallow
Rubble	H				3				[B]for the first few weeks
Gravel	H	H[A]		H	3	3		2	
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Stuart and Chislett 1979
None									2. Hopcraft et al. 1995
Submergents									3. Geen et al. 1966
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool				H				2	
Riffle				H				1	
Run	H				3				
Rapid									
River Margin									
Off-Channel									

Appendix 31: Stream habitat requirements for Salish sucker.

Species:	Salish sucker				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									[A]vegetation
Gravel	H				3				[B]glide
Sand				H				1	[C]overwintering
Silt/Clay		H	H	H		1	1	1	
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Inglis et al. 1992
Submergents				H^A				1	2. Pearson 1998
Emergents				H^A				1	3. McPhail and Taylor 1996
Algae									
Wood									
In Situ									
Substrate									
Overhead		H	H	H		1	1	1	
Other									
Velocity/Habitat:									
Pool		H	H	H		1	1	1	
Riffle	H	H	H		3	1	1		
Run	M	H^B	H	H^B	3	1	1		
Rapid									
River Margin									
Off-Channel				M^C				2	

Appendix 32: Stream habitat requirements for bridgelip sucker.

Species:	Bridgelip sucker				**Morph:**	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20		H				1			H = nearly always associated
20-60		H				1			M = frequently associated
60-100			H[B]	H[B]			1	1	L = infrequently associated
100-200			H	H			1	1	Nil = not associated
200+			H	H			1	1	blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder			H	H			1	1	**Comments**
Cobble		H[A]		*H*		1		*2*	[B]at night
Rubble		H[A]		*H*		1		*2*	[A]rocky substrate
Gravel				H				2	
Sand				L				2	
Silt/Clay		H				1			
Muck (Detritus)				L				2	
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Dauble 1980
Submergents									2. Scott and Crossman 1973
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool		H	H	H		1	1	1	
Riffle			H	H			1	1	
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 33: Stream habitat requirements for white sucker.

Species:	White sucker				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60	H				2,3				M = frequently associated
60-100	H				1				L = infrequently associated
100-200	H				1				Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									[A]drift to lake
Gravel	H				1,2				
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic		H[A]				2			
Cover:									**References**
None									1. Scott and Crossman 1973
Submergents									2. Nelson 1968c
Emergents									3. Emery 1973
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool	H				1,2				
Riffle	H				2				
Run	H				2				
Rapid	H				2				
River Margin									
Off-Channel									

Appendix 34: Stream habitat requirements for largescale sucker.

Species:	Largescale sucker				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20		H	H	H		2	2	2	H = nearly always associated
20-60		H	H	H		2	2	2	M = frequently associated
60-100	*H*	H	H	H	1	2	2	2	L = infrequently associated
100-200	*H*	H		M[B]	1	2		2	Nil = not associated
200+	*H*	H		H[C]	1	2		2	blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble	*M*	H	M		2	2	2		**Comments**
Rubble	*M*				2				[B]sub-adult
Gravel	M				3				[C]larger adult
Sand	H				1,3				[D]mainstem river
Silt/Clay									[E]after sunset
Muck (Detritus)		H				2			
Hard-pan Clay									
Pelagic		H				2			
Cover:									**References**
None									1. Nelson 1968c
Submergents									2. Dauble 1986
Emergents		H				4,5			3. Scott and Crossman 1973
Algae									4. Clemens et al. 1939
Wood									5. McPhail and Lindsey 1970
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool	H[A]	M			1	2			
Riffle	*H*				2				
Run			M[D]	H[D]			2	2	
Rapid									
River Margin		H		H[E]		2		2	
Off-Channel		M	H			2	2		

Appendix 35: Stream habitat requirements for mountain sucker.

Species:	Mountain sucker				Morph:	Freshwater only			Legend/Comments/References
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20		H		H		H		1	H = nearly always associated
20-60		H		H		H		1	M = frequently associated
60-100				H				1	L = infrequently associated
100-200				H				1	Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock				H				1	grayed = not present in freshwater
Boulder				H				1	
Cobble				H				1	**Comments**
Rubble				H				1	
Gravel				H				1	
Sand				H				1	
Silt/Clay				H					
Muck (Detritus)									
Hard-pan Clay									**References**
Pelagic									1. Campbell 1992
Cover:									2. Smith 1966
None			H	H			3	1,2	3. Hauser 1969
Submergents			H	M			3	1,2	4. Scott and Crossman 1973
Emergents									
Algae									
Wood				H				3	
In Situ Substrate			*H*[A]	*H*[A]					
Overhead						3			
Other									
Velocity/Habitat:			H	H			3	3,4	
Pool				H	3			3	
Riffle	H			H		3		3	
Run		H							
Rapid									
River Margin			H			3			
Off-Channel									

Appendix 36: Stream habitat requirements for black bullhead.

Species:	Black bullhead				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	H[A]				1				H = nearly always associated
20-60	H[A]				1				M = frequently associated
60-100	H				2				L = infrequently associated
100-200	H				2				Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble									[A]shallow
Rubble									
Gravel	H				1				
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Scott and Crossman 1973
None									2. Bryan and Snarnecchia 1992
Submergents	H				1				
Emergents	H				1,2				
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel				H				1	

Appendix 37: Stream habitat requirements for brown bullhead.

Species:	Brown bullhead				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	H[A]				1				H = nearly always associated
20-60	H[A]				1				M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									[A]shallow
Gravel									[B]aquatic vegetation
Sand	H				1				
Silt/Clay									
Muck (Detritus)	H				1				
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Scott and Crossman 1973
Submergents				H[B]				1	
Emergents				H[B]				1	
Algae									
Wood	H				1				
In Situ									
Substrate	H				1				
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 38: Stream habitat requirements for northern pike.

Species:	Northern pike				**Morph:**	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	H	*H*			1	*1*			H = nearly always associated
20-60	H	*H*			1	*1*			M = frequently associated
60-100	M	*H*			1	*1*			L = infrequently associated
100-200			*H*	*H*			*1*	*1*	Nil = not associated
200+			*H*	*H*			*1*	*1*	blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulde									**Comments**
Cobble									
Rubble									
Gravel									
Sand	M		L	L	2,3		4,5,6	4,5,6	
Silt/Clay	M				2,3				
Muck (Detritus)	H	H	H	H	2,3	1,2	4,5,6	4,5,6	
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Casselman and Lewis 1996
None									2. Holland and Huston 1984
Submergents	H	H	H	H	1,2	1	1,2	1	3. Scott and Crossman 1973
Emergents	H	M	H	H	1,2	1	1,2	1	4. Diana et al. 1977
Algae									5. Ford et al. 1995
Wood									6. Eklov 1997
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel	H	H	H	H	1	1	1	1	

Appendix 39: Stream habitat requirements for pond smelt.

Species:	Pond smelt				Morph:	Marine and freshwater				
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble									
Rubble									
Gravel									
Sand									
Silt/Clay									
Muck (Detritus)	H				1				
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Morrow 1980
None									
Submergents									
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 40: Stream habitat requirements for surf smelt.

Species:	Surf smelt				**Morph:**	Marine and freshwater			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									
Gravel									
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic				*H*				1,2	
Cover:									**References**
None									1. Haas 1998
Submergents									2. Morrow 1980
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 41: Stream habitat requirements for rainbow smelt.

Species:	Rainbow smelt				**Morph:**	Anadromous			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	H				3				H = nearly always associated
20-60	H				3				M = frequently associated
60-100	H				3				L = infrequently associated
100-200	H				3				Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder	M				1				**Comments**
Cobble	M				1				^moderate flow
Rubble	M				1				
Gravel	H				1,2				
Sand	M				1				
Silt/Clay	M				1				
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Morrow 1980
Submergents	H								2. Scott and Crossman 1973
Emergents					1				3. Bradbury et al. 1999
Algae									
Wood	H				1				
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run	*H*^				2				
Rapid									
River Margin									
Off-Channel									

Appendix 42: Stream habitat requirements for eulachon.

Species:	Eulachon				**Morph:**	Anadromous			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20		H				2			H = nearly always associated
20-60		H				2			M = frequently associated
60-100		H				2			L = infrequently associated
100-200		H				2			Nil = not associated
200+	H	H			1	2			blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									
Gravel									
Sand	H				1				
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic		H				2			
Cover:									**References**
None									1. Scott and Crossman 1973
Submergents									2. Hay and McCarter 2000
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 43: Stream habitat requirements for Arctic cisco.

Species:	Arctic cisco				Morph:	Anadromous			Legend/Comments/References
Habitat Features: Categories Stream Usage:	Ratings				Sources				
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									[B]drift to ocean
Gravel	H								[A]swift water
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic		H[B]							**References**
Cover:									1. Scott and Crossman 1973
None									
Submergents									
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle	H[A]								
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 44: Stream habitat requirements for lake whitefish.

Species:	Lake whitefish				Morph:				
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60	H				1				M = frequently associated
60-100	H				1				L = infrequently associated
100-200	H				1				Nil = not associated
200+	H				1				blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder	H				2				**Comments**
Cobble	H				2				
Rubble	H				2				
Gravel	H				2				
Sand	M				3				
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. RL&L 1997
None									2. Machniak 1975
Submergents									3. Ford et al. 1995
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle	H				1				
Run									
Rapid	H				1				
River Margin									
Off-Channel									

Appendix 45: Stream habitat requirements for broad whitefish.

Species:	Broad whitefish				Morph:	Freshwater and brackish water			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									
0-20									**Legend**
20-60									H = nearly always associated
60-100									M = frequently associated
100-200									L = infrequently associated
200+									Nil = not associated
Substrate:									blank = no information
Bedrock									*italicized* = based on other information
Boulder									grayed = not present in freshwater
Cobble									
Rubble									**Comments**
Gravel	H								
Sand					1				
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									
None									
Submergents									**References**
Emergents									1. Valtonen 1970
Algae									2. Treble and Tallman 1997
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel			H	H			2	2	

Appendix 46: Stream habitat requirements for least cisco.

Species:	Least cisco				Morph:	Anadromous			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	H[A]				1				H = nearly always associated
20-60	H[A]				1				M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									[A]shallow
Gravel	H				1				
Sand	H				1				
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. McPhail and Lindsey 1970
None									
Submergents									
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 47: Stream habitat requirements for amphidromous coastal cutthroat trout.

Species:	Coastal cutthroat trout				Morph:	Amphidromous			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	H				1				H = nearly always associated
20-60	H				1				M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder		H	H			2	2		**Comments**
Cobble		H	H			2	2		^glide
Rubble		H	H			2	2		
Gravel	H	H	H		1	2	2		
Sand		H	H			2	2		
Silt/Clay		H	H			2	2		
Muck (Detritus)		H	H			2	2		
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Trotter 1989
Submergents									2. Roberge 2000
Emergents									
Algae									
Wood		H	H	H		2	2	2	
In Situ		M	M			2	2		
Substrate		H	H	H		2	2	2	
Overhead									
Other									
Velocity/Habitat:									
Pool		H	H	H		2	2	2	
Riffle		L	L			2	2		
Run		M^	M^			2	2		
Rapid									
River Margin									
Off-Channel									

Appendix 48: Stream habitat requirements for stream resident coastal cutthroat trout.

Species:	Coastal cutthroat trout				**Morph:**	Stream resident			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20		H				3			H = nearly always associated
20-60		H				3			M = frequently associated
60-100		*H*				2			L = infrequently associated
100-200		*H*				2			Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder		H				3			**Comments**
Cobble									
Rubble									
Gravel	H				1				
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Moore and Gregory 1988
None									2. Bisson et al. 1988
Submergents									3. Griffin and Smith 1993
Emergents									
Algae									
Wood		H	H	H		2	2	2	
In Situ									
Substrate		H				2,3			
Overhead									
Other									
Velocity/Habitat:									
Pool		H	H	H		2	2	2	
Riffle									
Run			H	H			2	2	
Rapid									
River Margin		H				1,3			
Off-Channel			H	H			2	2	

Appendix 49: Stream habitat requirements for westslope cutthroat trout.

Species:	Westslope cutthroat trout				Morph:	Stream resident			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20		*H*				2			H = nearly always associated
20-60		*H*				2			M = frequently associated
60-100			*H*				2		L = infrequently associated
100-200			*H*				2		Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble		H	H			2,3	2,3		
Rubble		H	H			2,3	2,3		
Gravel	H	H	H		1	2,3	2,3		
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Ford et al. 1995
None									2. Moore and Gregory 1988
Submergents									3. Scarnecchia and Bergersen 1986
Emergents									4. Liknes and Graham 1988
Algae									
Wood									
In Situ			H	H			4	4	
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool		H	H	H		2	2	2	
Riffle									
Run									
Rapid									
River Margin		H	H	H		2	2	2	
Off-Channel		H	H	H		2	2	2	

Appendix 50: Stream habitat requirements for pink salmon.

Species:	Pink salmon				**Morph:**	Anadromous			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	H				4				H = nearly always associated
20-60	H				4				M = frequently associated
60-100	H				4				L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble	M				2,3				
Rubble	M				2,3				
Gravel	H				1,2,3				
Sand	M				2,3				
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Heard 1991
Submergents									2. Lucus 1959
Emergents									3. Bonar et al. 1989
Algae									4. Scott and Crossman 1973
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle	H				1				
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 51: Stream habitat requirements for chum salmon.

Species:	Chum salmon				Morph:	Anadromous			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20	H	H			5	1			H = nearly always associated
20-60	H	H			5	1			M = frequently associated
60-100		H				1			L = infrequently associated
100-200		H				1			Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									[A]swift water
Gravel	H				3				
Sand	L				4				
Silt/Clay	L				4				
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Gregory and Levings 1998
Submergents		H				2,6			2. Gregory and Levings 1996
Emergents									3. Sano 1959
Algae									4. Burner 1951
Wood									5. Johnson et al. 1971
In Situ									6. Salo 1991
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle	H[A]				5				
Run	H[A]				5				
Rapid									
River Margin									
Off-Channel									

Appendix 52: Stream habitat requirements for coho salmon.

Species:	Coho salmon				Morph:	Anadromous			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20	H^A		H		2		4		H = nearly always associated
20-60	H^A	H	H		2	3	3,4		M = frequently associated
60-100			H				3,4		L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble			H				4		**Comments**
Rubble			H				4		^shallow
Gravel	H		M		2		4		
Sand			M				4		
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Bell et al. 2001
Submergents									2. Scott and Crossman 1973
Emergents									3. Tschaplinski and Hartman 1983
Algae									4. Bravender and Shirvell 1990
Wood		H	H			3	3,9,10		5. Montgomery et al. 1999
In Situ		H	H			3,7	3		6. Hankin and Reeves 1988
Substrate									7. Bisson et al. 1988
Overhead		H	H			3	3,10		8. Murphy et al. 1989
Other									9. Nickelson et al. 1992
Velocity/Habitat:									10. McMahon and Hartman 1989
Pool	H	H	H		5	3	1,3,4,6,8,10		
Riffle	H		M		5		6		
Run									
Rapid									
River Margin		H				3,7			
Off-Channel		H	H			3,7	1,8		

Appendix 53: Stream habitat requirements for freshwater resident rainbow trout.

Species:	Rainbow trout				Morph:	Freshwater resident			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder			*H*	H^			*3*	3	**Comments**
Cobble			*H*	H^			*3*	3	^larger substrate
Rubble			*H*	H^			*3*	3	
Gravel	H		*H*	H	2		*3*	3	
Sand									
Silt/Clay	Nil				1				
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Ford et al. 1995
Submergents									2. Scott and Crossman 1973
Emergents									3. Hopcraft et al. 1995
Algae									
Wood	M		M	M	1		3	3	
In Situ							*3*	3	
Substrate			*M*	M					
Overhead	M		*H*	H	1		*3*	3	
Other									
Velocity/Habitat:									
Pool			*M*	M			*3*	3	
Riffle	H		*H*	H	2		*3*	3	
Run			*H*	H			*3*	3	
Rapid									
River Margin									
Off-Channel									

Appendix 54: Stream habitat requirements for anadromous rainbow trout (steelhead).

Species:	Rainbow trout - Steelhead				Morph:	Anadromous			Legend/Comments/References
Habitat Features: Categories Stream Usage:	Ratings				Sources				
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20	H	H			7,8	3,6			H = nearly always associated
20-60	H	H	H		7,8	3,6	3,4		M = frequently associated
60-100	H	M	H		8	3	3,4		L = infrequently associated
100-200	H	M	H		8	3	3,4		Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder		L	M			3	3		
Cobble		M	H			3	3		**Comments**
Rubble	M	H	H		8	3	3		
Gravel	H	H	H		7,8	3	3		
Sand		M	H			3,5	3,5		
Silt/Clay		M	M			5	5		
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									**References**
None		H	M			3,5	5		1. Roper et al. 1994
Submergents									2. Hankin and Reeves 1988
Emergents									3. Pearlstone 1976
Algae									4. Beecher et al. 1993
Wood		M	H			3	3,6		5. Bradford and Higgins 2001
In Situ									6. Bustard 1973
Substrate		H	M			3,6	3		7. Hunter 1973
Overhead		L	M			3	3		8. Orcutt et al. 1968
Other									
Velocity/Habitat:									
Pool			H				1,2,3,4		
Riffle	H	H	H		7,8	3	1,2,3		
Run			M				4		
Rapid									
River Margin		H	M			5,6	5		
Off-Channel									

Appendix 55: Stream habitat requirements for sockeye salmon.

Species:	Sockeye salmon				Morph:	Anadromous			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	H	H			4,5	1			H = nearly always associated
20-60	H	H			4,5	1			M = frequently associated
60-100	H	H			4,5	1			L = infrequently associated
100-200		H				1			Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble									
Rubble									
Gravel	H				3				
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Gregory and Levings 1998
None									2. Gregory and Levings 1996
Submergents			M				2		3. Burgner 1991
Emergents									4. Hendry and Quinn 1997
Algae									5. Fukushima and Smoker 1998
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel		H				3			

Appendix 56: Stream habitat requirements for landlocked sockeye salmon (kokanee).

Species:	Sockeye salmon - Kokanee				**Morph:**	Freshwater resident, landlocked			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	H				1,2,3				H = nearly always associated
20-60	H				1,2,3				M = frequently associated
60-100	H				1,2,3				L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble	H				1				
Rubble	H				1				
Gravel	H				1				
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Burgner 1991
None									2. Scott and Crossman 1973
Submergents									3. Ford et al. 1995
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 57: Stream habitat requirements for chinook salmon.

Species:	Chinook salmon				Morph:	Anadromous			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	**YOY**	**Juvenile**	**Adult**	**Spawn/Egg**	**YOY**	**Juvenile**	**Adult**	
Depth: (cm)									**Legend**
0-20	H	H	H		3	4	6,7		H = nearly always associated
20-60	H	H	H		3	4	6,7		M = frequently associated
60-100	H	H	H		3	4	7		L = infrequently associated
100-200	H	H			3	4			Nil = not associated
200+	H	H			2,3	9			blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder			H			5			
Cobble	H		H		2	5			**Comments**
Rubble	H		H		2	5			[A]aquatic vegetation
Gravel	H		M		3	7			
Sand	H		M		1	7			
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Scott and Crossman 1973
Submergents		M[A]	M[A]			9	9		2. Dauble et al. 1999
Emergents		M[A]	M[A]			9	9		3. Chapman 1943
Algae									4. Gregory and Levings 1998
Wood									5. Porter and Rosenfeld 1999
In Situ									6. McMichael and Pearsons 1998
Substrate		H				11			7. Bravender and Shirvell 1990
Overhead									8. Montgomery et al. 1999
Other									9. Gregory and Levings 1996
Velocity/Habitat:									10. Sommer et al. 2001
Pool	H		H		8				11. Bradford and Higgins 2001
Riffle	H		M		3,8				
Run			H						
Rapid									
River Margin		*M*				*9*			
Off-Channel		H	H			10			

Appendix 58: Stream habitat requirements for pygmy whitefish.

Species:	Pygmy whitefish				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings:** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	H^				1				H = nearly always associated
20-60	H^				1				M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									^shallow
Gravel	H				1				
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Scott and Crossman 1973
None									
Submergents									
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 59: Stream habitat requirements for round whitefish.

Species:	Round whitefish				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20	H				1				H = nearly always associated
20-60	H				1				M = frequently associated
60-100	H				1				L = infrequently associated
100-200	H				1				Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock					1				grayed = not present in freshwater
Boulder	H				1				
Cobble	H				1				**Comments**
Rubble	H				1				
Gravel	H								
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Normandeau 1969
None									
Submergents									
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 60: Stream habitat requirements for mountain whitefish.

Species:	Mountain whitefish				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	M	H			6	1,3			H = nearly always associated
20-60	H	H			3,5,6	1,3			M = frequently associated
60-100	H				3,5,6				L = infrequently associated
100-200	H				3,6				Nil = not associated
200+	H				3,6				blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder	H	H			3,5	1			**Comments**
Cobble	H	H	H	H	3,5	1	4	4	
Rubble	H	H	H	H	5,6	1	4	4	
Gravel	H	H	H	H	5,6	1	4	4	
Sand		H				1,3			
Silt/Clay		H				1,3			
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Stuart and Chislett 1979
None									2. Ford et al. 1995
Submergents			H	H			2	2	3. RL&L 1997
Emergents			H	H			2	2	4. Porter and Rosenfeld 1999
Algae									5. Thompson and Davies 1976
Wood			H	H			2	2	6. Brown 1952
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool			M	M			1	1	
Riffle	H	H	H	H	3,6	1	1,4	1,4	
Run		M	H	H		1	1	1	
Rapid	H				3,5				
River Margin		H				3			
Off-Channel		H				1,3,5			

Appendix 61: Stream habitat requirements for Atlantic salmon.

Species:	Atlantic salmon				Morph:	Anadromous			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20		H	H			3	3		H = nearly always associated
20-60		H	H			3	3		M = frequently associated
60-100			H				3		L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble		H	H			3	3		
Rubble		H	H			3	3		
Gravel	H	H	H		1,2	3	3		
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Scott and Crossman 1973
Submergents					1,2	3	3		2. Scott and Scott 1988
Emergents									3. Morantz et al. 1987
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle	H	H	H						
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 62: Stream habitat requirements for brown trout.

Species:	Brown trout				Morph:	Anadromous and freshwater resident			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20		H				2			H = nearly always associated
20-60		H				2			M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder		H				2			**Comments**
Cobble		H				2			
Rubble									
Gravel	H				1				
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Scott and Scott 1988
None									2. Griffin and Smith 1993
Submergents									
Emergents									
Algae									
Wood									
In Situ									
Substrate		H				2			
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 63: Stream habitat requirements for Arctic char.

Species:	Arctic char				Morph:	Anadromous and freshwater resident			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									
0-20									**Legend**
20-60									H = nearly always associated
60-100									M = frequently associated
100-200	H								L = infrequently associated
200+	H				I				Nil = not associated
Substrate:					I				blank = no information
Bedrock									*italicized* = based on other information
Boulder									grayed = not present in freshwater
Cobble									
Rubble									**Comments**
Gravel									
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									
None									
Submergents									**References**
Emergents									1. Scott and Crossman 1973
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool	H								
Riffle					I				
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 64: Stream habitat requirements for bull trout.

Species:	Bull trout				Morph:	Anadromous and freshwater resident			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20		H	H			2,3	2		H = nearly always associated
20-60	H	H	H		2	2,3	2		M = frequently associated
60-100		M	H			2	2		L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder		H	H	H		3	2,7	1	**Comments**
Cobble		H	H	H		2,3	2,7	1	
Rubble	H		H	H	2		2	1	
Gravel	H				2				
Sand			M[A]				2		
Silt/Clay		M	M[A]			2	2,7		
Muck (Detritus)									
Hard-pan Clay									
Pelagic			M[A]				7		
Cover:									**References**
None			H				2		1. Hopcraft et al. 1995
Submergents									2. from Baxter and McPhail 1996
Emergents									3. Baxter 1997
Algae									4. McPhail and Murray 1979
Wood	H	H	H[B]	H	2	2,3	3,5		5. Allan 1987
In Situ	H	H	H	H	2	2	5		6. McPhail and Baxter 1996
Substrate		H	H	H		2,3	2,3,5		7. Baxter and McPhail 1997
Overhead	H	H	H	H	2	2,3	3,5		
Other									
Velocity/Habitat:									
Pool	H	H	H[C]		2	2,4	2,6		
Riffle	L			H	2			1	
Run	H		H[D]	H	2		6	1	
Rapid									
River Margin									
Off-Channel		H				4			

Appendix 65: Stream habitat requirements for brook trout.

Species:	Brook trout				Morph:	Anadromous and Stream resident			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									
Gravel	H				1				
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Scott and Crossman 1973
Submergents									2. Wurtsbaugh et al. 1975
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead		H	H			2	2		
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 66: Stream habitat requirements for Dolly Varden.

Species:	Dolly Varden				Morph:	Freshwater resident			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60				L				1	M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									[A]moderate velocity
Gravel	H				2				[B]overwinter
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Stuart and Chislett 1979
Submergents									2. Scott and Crossman 1973
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle				H				1	
Run	H[A]				2				
Rapid									
River Margin									
Off-Channel				M[B]				1	

Appendix 67: Stream habitat requirements for anadromous Dolly Varden.

Species:	Dolly Varden				**Morph:**	Anadromous			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble									^moderate velocity
Rubble									
Gravel	H	H			1	2			
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Scott and Crossman 1973
Submergents									2. Smith and Slaney 1980
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool		L	L			2	2		
Riffle		H	H			2	2		
Run	*H*^	H	H		*1*	2	2		
Rapid									
River Margin									
Off-Channel									

Appendix 68: Stream habitat requirements for lake trout.

Species:	Lake trout				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									
0-20									**Legend**
20-60									H = nearly always associated
60-100									M = frequently associated
100-200									L = infrequently associated
200+									Nil = not associated
Substrate:									blank = no information
Bedrock									*italicized* = based on other information
Boulder	H								grayed = not present in freshwater
Cobble					l				
Rubble									**Comments**
Gravel	H								
Sand					l				
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									
None									
Submergents									
Emergents									**References**
Algae									1. Loftus 1957
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel	H				l				

Appendix 69: Stream habitat requirements for inconnu.

Species:	Inconnu				Morph:	Anadromous and Freshwater Resident			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200	H				1				Nil = not associated
200+	H				1				blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble									[A]fast flowing
Rubble									
Gravel	H				1				
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. ADFG 2002
None	H				1				
Submergents									
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle	H[A]				1				
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 70: Stream habitat requirements for Arctic grayling.

Species:	Arctic grayling				**Morph:**	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20		H		M		5,6		2,8,9	H = nearly always associated
20-60		H	H	H		6	3,6	2,8,9	M = frequently associated
60-100			H	H			3,6	2,8,9	L = infrequently associated
100-200				H				6	Nil = not associated
200+				H				6	blank = no information
Substrate:									*italicized* = based on other information
Bedrock				H				6	grayed = not present in freshwater
Boulder		H		H		2,6		6,7	**Comments**
Cobble		H	H			2,6	3		[A]in large rivers
Rubble	H	H			1	4			[B]>2+
Gravel	H	H		H	1	4,6		7	
Sand		H				2,6			
Silt/Clay		M				4,6			
Muck (Detritus)	L				1				
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Scott and Crossman 1973
None									2. Ford et al. 1995
Submergents		H				6			3. Northcote 1993
Emergents		H				6			4. Lucko 1992
Algae									5. McClure and Gould 1991
Wood		*H*				6			6. Stuart and Chislett 1979
In Situ									7. Schmidt and O'Brien 1982
Substrate		H				6			8. Hubert et al. 1985
Overhead		H				6			9. Liknes and Gould 1987
Other									
Velocity/Habitat:									
Pool	H[A]		H[B]	H	1		3,6	6	
Riffle			H	H			6	6	
Run			H	H			6	6	
Rapid									
River Margin									
Off-Channel		H	H	H		6	6	6	

Appendix 71: Stream habitat requirements for trout-perch.

Species:	Trout-perch				**Morph:**	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	H[A]			H[A]	1			1,2	H = nearly always associated
20-60	H[A]			H[A]	1			1,2	M = frequently associated
60-100				H[B]				2	L = infrequently associated
100-200				H[B]				2	Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble	H[C]				1				**Comments**
Rubble	H[C]				1				[A]shallow
Gravel	H[C]				1				[B]deep
Sand									[C]rocky
Silt/Clay									
Muck (Detritus)				H				1	
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Scott and Crossman 1973
Submergents									2. Morrow 1980
Emergents									
Algae									
Wood				H				2	
In Situ				H				2	
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool				H				2	
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 72: Stream habitat requirements for burbot.

Species:	Burbot				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60	H[A]				1				M = frequently associated
60-100	H[A]				1				L = infrequently associated
100-200	H[A]		H	H	1		7	6	Nil = not associated
200+			H				7		blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble	H	H[B]	H		8	3	2,3		[A]below ice
Rubble	H	H[B]	H		8	3	2,3		[B]rocky
Gravel	H	H[B]	H		3,8	3	2,3		
Sand	H	M	M		3,8	4	4		
Silt/Clay									
Muck (Detritus)					1				
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Sorokin 1971
None									2. Porter and Rosenfeld 1999
Submergents									3. Scott and Crossman 1973
Emergents		H	M			3,5	3,7		4. Hanson and Qadri 1980
Algae									5. from McPhail and Paragamian 2000
Wood		M	M			4	4		6. Breeser et al. 1988
In Situ		H	M			4,5	4		7. Fisher 2000
Substrate	H	H			1	5			8. Ford et al.. 1995
Overhead									
Other									
Velocity/Habitat:									
Pool	H								
Riffle									
Run									
Rapid									
River Margin				H				6	
Off-Channel	H	H	H		7	7	7		

Appendix 73: Stream habitat requirements for brook stickleback.

Species:	Brook stickleback				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									
0-20									**Legend**
20-60									H = nearly always associated
60-100									M = frequently associated
100-200									L = infrequently associated
200+									Nil = not associated
Substrate:									blank = no information
Bedrock									*italicized* = based on other information
Boulder									grayed = not present in freshwater
Cobble									
Rubble									**Comments**
Gravel									^dense vegetation
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									
None									
Submergents									
Emergents				H^					**References**
Algae				H^					1. Scott and Crossman 1973
Wood								1	
In Situ								1	
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 74: Stream habitat requirements for threespine stickleback.

Species:	Threespine stickleback				Morph:	Anadromous			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble									[A]vegetation
Rubble									
Gravel									
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Narver 1969
None									
Submergents	H[A]				1				
Emergents	H[A]				1				
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 75: Stream habitat requirements for coastrange sculpin.

Species:	Coastrange sculpin				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									
0-20				H				1	**Legend**
20-60				H				1	H = nearly always associated
60-100				H				1	M = frequently associated
100-200									L = infrequently associated
200+									Nil = not associated
Substrate:									blank = no information
Bedrock									*italicized* = based on other information
Boulder									grayed = not present in freshwater
Cobble									
Rubble									**Comments**
Gravel	H			H	2,3			4	
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									
None									**References**
Submergents									1. White and Harvey 1999
Emergents									2. Ricker 1960
Algae									3. Scott and Crossman 1973
Wood									4. Mason and Machidori 1976
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle	H			H	2,3			1	
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 76: Stream habitat requirements for prickly sculpin.

Species:	Prickly sculpin				**Morph:**	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20				H[A]				3	H = nearly always associated
20-60				H[A]				3	M = frequently associated
60-100									L = infrequently associated
100-200				H				1	Nil = not associated
200+				H				1	blank = no information
Substrate:									*italicized* = based on other information
Bedrock	H				4				grayed = not present in freshwater
Boulder	H				4				**Comments**
Cobble	H			H	4			3	[A]shallow
Rubble				H				3	[B]fast velocity
Gravel				H				3	
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. White and Harvey 1999
None									2. Mason and Machidori 1976
Submergents									3. Porter and Rosenfeld 1999
Emergents									4. Scott and Crossman 1973
Algae									
Wood									
In Situ									
Substrate	H				4				
Overhead									
Other									
Velocity/Habitat:									
Pool				H				1,2	
Riffle				H[B]				3	
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 77: Stream habitat requirements for mottled sculpin.

Species:	Mottled sculpin				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20		H				3			H = nearly always associated
20-60		M				3		?	M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble				H^				1,2	^stones
Rubble				H^				1,2	
Gravel				H^				1,2	
Sand									
Silt/Clay									
Muck (Detritus)		H				3			
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Hughes and Peden 1984
None									2. Peden and Hughes 1984b
Submergents									3. Scott and Crossman 1973
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 78: Stream habitat requirements for slimy sculpin.

Species:	Slimy sculpin				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder				H				1	**Comments**
Cobble				H				1,2	
Rubble				H				1,2	
Gravel				H				2,3	
Sand				M				2	
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Hopcraft et al. 1995
None				M				1	2. McPhail and Lindsey 1970
Submergents									3. Scott and Crossman 1973
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle				H				1	
Run				H				1	
Rapid									
River Margin									
Off-Channel									

Appendix 79. Stream habitat requirements for shorthead sculpin.

Species:	Shorthead sculpin				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder	H				1				**Comments**
Cobble	H^				1				^large rock
Rubble				H				3	
Gravel				H				3	
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Lee et al. 1980
Submergents									2. Scott and Crossman 1973
Emergents									3. Cannings and Ptolemy 1998
Algae									
Wood									
In Situ									
Substrate	H				1				
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle	H			H	1			2	
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 80: Stream habitat requirements for torrent sculpin.

Species:	Torrent sculpin				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble									
Rubble				H				1	
Gravel				H				1	
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Page and Burr 1991
None									
Submergents									
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle				H				1	
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 81: Stream habitat requirements for spoonhead sculpin.

Species:	Spoonhead sculpin				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									**Comments**
Cobble				H^				1	^rocky
Rubble				H^				1	
Gravel				H^				1	
Sand									
Silt/Clay									
Muck (Detritus)				H				2	
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Page and Burr 1991
None									2. Scott and Crossman 1973
Submergents									
Emergents									
Algae									
Wood									
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 82: Stream habitat requirements for smallmouth bass.

Species:	Smallmouth bass				**Morph:**	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100	H				1				L = infrequently associated
100-200	H				1				Nil = not associated
200+	H				1				blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder		H				2			**Comments**
Cobble		H				2			
Rubble	H[A]	H			1	2			
Gravel	H[A]	H			1	2			
Sand	H	H			1	2			
Silt/Clay		H				2			
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Scott and Crossman 1973
None									
Submergents	L	H			1	2			
Emergents	L				1				
Algae									
Wood	H				1				
In Situ									
Substrate	H				1				
Overhead									
Other									
Velocity/Habitat:									
Pool		H				2			
Riffle									
Run		H				2			
Rapid									
River Margin									
Off-Channel									

Appendix 83: Stream habitat requirements for black crappie.

Species:	Black crappie				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings** Spawn/Egg	YOY	Juvenile	Adult	**Sources** Spawn/Egg	YOY	Juvenile	Adult	**Legend/Comments/References**
Depth: (cm)									**Legend**
0-20	H				1				H = nearly always associated
20-60	H				1				M = frequently associated
60-100	H				1				L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									[A]vegetation
Gravel									
Sand									
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									**References**
Cover:									1. Scott and Crossman 1973
None									
Submergents	H[A]				1				
Emergents	H[A]				1				
Algae									
Wood	H				1				
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 84: Stream habitat requirements for yellow perch.

Species:	Yellow perch				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100									L = infrequently associated
100-200									Nil = not associated
200+									blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder									
Cobble									**Comments**
Rubble									
Gravel	M				1				
Sand	M				1				
Silt/Clay									
Muck (Detritus)									
Hard-pan Clay									
Pelagic									
Cover:									**References**
None									1. Scott and Crossman 1973
Submergents	H				1				
Emergents	H				1				
Algae									
Wood	H				1				
In Situ									
Substrate									
Overhead									
Other									
Velocity/Habitat:									
Pool									
Riffle									
Run									
Rapid									
River Margin									
Off-Channel									

Appendix 85: Stream habitat requirements for walleye.

Species:	Walleye				Morph:	Freshwater only			
Habitat Features: Categories Stream Usage:	**Ratings**				**Sources**				**Legend/Comments/References**
	Spawn/Egg	YOY	Juvenile	Adult	Spawn/Egg	YOY	Juvenile	Adult	
Depth: (cm)									**Legend**
0-20									H = nearly always associated
20-60									M = frequently associated
60-100	H			M	4,5			4	L = infrequently associated
100-200	H			H	4,5			4	Nil = not associated
200+	H			H	4,5			4	blank = no information
Substrate:									*italicized* = based on other information
Bedrock									grayed = not present in freshwater
Boulder	M			L				4	**Comments**
Cobble	H			H				4	[A]during summer
Rubble	H			H				4	[B]post-spawning
Gravel	H			H				4	[C]during winter
Sand	M			M				4	
Silt/Clay				M				4	
Muck (Detritus)									
Hard-pan Clay	M								
Pelagic									
Cover:									**References**
None	*H*			H[A]				4	1. DiStefano and Hiebert 2000
Submergents				H				2	2. Scott and Crossman 1973
Emergents									3. Stevens 1990
Algae									4. Paragamian 1989
Wood	*H*			H[B]				4	5. Pitlo 1989
In Situ									6. Lubinski 1984
Substrate	*L*			H[C]	3			4	
Overhead									
Other									
Velocity/Habitat:									
Pool	H			H	1,2,3,4			4	
Riffle	H				4				
Run	*H*				4				
Rapid	*H*				4				
River Margin	H				1,5				
Off-Channel									

Appendix 86: List of freshwater fish species occurring in British Columbia. Data taken and modified from McPhail and Carveth (1993b).

Common Name	Scientific Name	Fra	Col	Mac	Yuk	NC	CC	QCI	VI
Lampreys	Petromyzontidae								
River lamprey	*Lampetra ayresi*	X				X	X		X
Arctic lamprey	*Lampetra japonica*				X				
Lake lamprey	*Lampetra macrostoma*								X
Western brook lamprey	*Lampetra richardsoni*	X				X	X	X	X
Pacific lamprey	*Lampetra tridentata*	X				X	X	X	X
Sturgeons	Acipenseridae								
Green sturgeon	*Acipenser medirostris*	X				X	X		X
White sturgeon	*Acipenser transmontanus*	X	X			X	X		
Mooneyes	Hiodontidae								
Goldeye	*Hiodon alosoides*			X					
Herrings	Clupeidae								
American shad	*Alosa sapidissima*	I				I	I		
Carps and Minnows	Cyprinidae								
Chiselmouth	*Acrocheilus alutaceus*	X	X						
Goldfish	*Carassius auratus*	X	I						I
Lake chub	*Couesius plumbeus*	X	X	X	X	X	X		
Common carp	*Cyprinus carpio*	X	I/X						I
Brassy minnow	*Hybognathus hankinsoni*	X		X					
Pearl dace	*Margariscus margarita*			X					
Peamouth chub	*Mylocheilus caurinus*	X	X	X			X		X
Emerald shiner	*Notropis atherinoides*			X					
Spottail shiner	*Notropis hudsonius*			X					
Northern redbelly dace	*Phoxinus eos*			X					
Finescale dace	*Phoxinus neogaeus*			X					
Fathead minnow	*Pimephales promelas*	I		I					I
Flathead chub	*Platygobio gracilis*			X					
Northern pikeminnow	*Ptychocheilus oregonensis*	X	X	X			X		
Longnose dace	*Rhinichthys cataractae*	X	X	X			X		
Leopard dace	*Rhinichthys falcatus*	X	X						
Speckled dace	*Rhinichthys osculus*		X						
Umatilla dace	*Rhinichthys umatilla*		X						
Redside shiner	*Richardsonius balteatus*	X	X	X			X		
Tench	*Tinca tinca*		I						
Suckers	Catostomidae								
Longnose sucker	*Catostomus catostomus*	X	X	X	X	X	X		
Bridgelip sucker	*Catostomus columbianus*	X	X						
White sucker	*Catostomus commersoni*	X		X					
Largescale sucker	*Catostomus macrocheilus*	X	X	X			X		
Mountain sucker	*Catostomus platyrhynchus*	X	X						

X=species present in watershed, I=species introduced to watershed, Fra=Fraser River watershed, Col=Columbia River watershed, Mac=Mackenzie River watershed, Yuk=Yukon River watershed, NC=North Coast watersheds, CC=Central Coast watersheds, QCI=Queen Charlotte Islands, VI=Vancouver Island

Appendix 86. Continued.

Common Name	Scientific Name	Fra	Col	Mac	Yuk	NC	CC	QCI	VI
Bullhead Catfishes	Ictaluridae								
Black bullhead	*Ameiurus melas*		I						
Brown bullhead	*Ameiurus nebulosus*	I	I						I
Pikes	Esocidae								
Northern pike	*Esox lucius*			X	X	X			
Smelts	Osmeridae								
Pond smelt	*Hypomesus olidus*				X				
Surf smelt	*Hypomesus pretiosus*	X							
Rainbow smelt	*Osmerus mordax*				X	X			X
Longfin smelt	*Spirinchus thaleichthys*	X				X	X		X
Eulachon	*Thaleichthys pacificus*	X				X	X	X	X
Trouts and Salmons	Salmonidae								
Cisco	*Coregonus artedi*			X					
Arctic cisco	*Coregonus autumnalis*			X					
Lake whitefish	*Coregonus clueaformis*	I/X	I	X	X	X	X		
Bering cisco	*Coregonus laurettae*				X				
Broad whitefish	*Coregonus nasus*				X				
Least cisco	*Coregonus sardinella*				X				
Cutthroat trout	*Oncorhynchus clarki*	X	X			X	X	X	X
Pink salmon	*Oncorhynchus gorbuscha*	X				X	X	X	X
Chum salmon	*Oncorhynchus keta*	X			X	X	X	X	X
Coho salmon	*Oncorhynchus kisutch*	X				X	X	X	X
Rainbow trout	*Oncorhynchus mykiss*	X	X	X		X	X	X	X
Sockeye salmon	*Oncorhynchus nerka*	X	I/X			X	X	X	X
Chinook salmon	*Oncorhynchus tshawytscha*	X			X	X	X	X	X
Pygmy whitefish	*Prosopium coulteri*	X	X	X	X	X	X		
Round whitefish	*Prosopium cylindraceum*			X	X	X			
Mountain whitefish	*Prosopium williamsoni*	X	X	X		X	X		
Atlantic salmon	*Salmo salar*								I
Brown trout	*Salmo trutta*		I						I
Arctic char	*Salvelinus alpinus*			X	X				
Bull trout	*Salvelinus confluentus*	X	X	X	X	X	X		
Brook trout	*Salvelinus fontinalis*	I	I	I					I
Dolly Varden trout	*Salvelinus malma*	X		X		X	X	X	X
Lake trout	*Salvelinus namaycush*	X	I	X	X	X	X		
Inconnu	*Stenodus leucichthys*			X	X				
Arctic grayling	*Thymallus arcticus*		I	X	X	X			
Trout-Perches	Percopsidae								
Trout-perch	*Percopsis omiscomaycus*			X					
Cods	Gadidae								
Burbot	*Lota lota*	X	X	X	X	X	X		
Sticklebacks	Gasterosteidae								
Brook stickleback	*Culaea inconstans*			X					
Threespine stickleback	*Gasterosteus aculeatus*	X				X	X	X	X
Ninespine stickleback	*Pungitius pungitius*			X					

Appendix 86. Continued.

Common Name	Scientific Name	Fra	Col	Mac	Yuk	NC	CC	QCI	VI
Sculpins	Cottidae								
Coastrange sculpin	*Cottus aleuticus*	X				X	X	X	X
Prickly sculpin	*Cottus asper*	X	X	X		X	X	X	X
Mottled sculpin	*Cottus bairdi*		X						
Slimy sculpin	*Cottus cognatus*	X	X	X	X	X			
Shorthead sculpin	*Cottus confusus*		X						
Torrent sculpin	*Cottus rhotheus*	X	X						
Spoonhead sculpin	*Cottus ricei*			X					
Sunfishes	Centrarchidae								
Pumpkinseed	*Lepomis gibbosus*	I	I						I
Smallmouth bass	*Micropterus dolomieu*		I						I
Largemouth bass	*Micropterus salmoides*	I	I						
Black crappie	*Pomoxis nigromaculatus*	I	I						
Perches	Percidae								
Yellow perch	*Perca flavescens*		I/X	X					
Walleye	*Stizostedion vitreum*		I	X					

GLOSSARY OF TERMS

Adhesive – Sticking or clinging.

Adult – Life stage of fish where they have matured and are able to reproduce.

Aquatic plants/vegetation – Plants whose photosynthetically active parts are permanently, or at least for several months each year, submerged in, or floating on, freshwater.

Alevin – Embryonic development stage of salmonid fish species which occurs between hatching from the egg, and before the absorption of the yolk sac and emergence from spawning gravel.

Allopatric – Species inhabiting geographically separated areas from other stocks of the same species.

Ammocoete – The larval form of lampreys.

Amphidromous – Fish which breed in freshwater, and remain in freshwater for some time before entering the ocean.

Anadromous – Fish which breed in freshwater but spend most of their adult life at sea, also commonly referred to as sea-run.

Aquatic – Living in water (freshwater, estuarine or marine).

Benthic – Living on, in or near the bottom of aquatic habitats.

Cover – Features within the aquatic environment that may be used by fish for protection (or refuge) from predators, competitors and adverse environmental conditions.

Demersal – Living on or near the bottom of a lake, often said of fishes and fish eggs.

Depth – Distance from the water surface.

Detritus – Organic material from dead organisms (plant and/or animal).

Diel – Within a 24 hour period, usually including night and day.

Emergent vegetation – Aquatic plants which grow on water-saturated or submerged soils and extend their stems and leaves above the surface of the water (e.g. cattails, grasses, sedges and rushes.

Estuary – A semi-enclosed body of water which has a free connection with the open ocean and within which saltwater is measurably diluted with freshwater derived from land drainage.

Eutrophy – Water rich in nutrients.

Exotic species – Species introduced to an area where it does not occur naturally.

Fish habitat – Aquatic areas on which fish depend either directly or indirectly in order to carry out their life processes.

Hybrid – The offspring of parents of different species. Hybrids are generally infertile or have reduced viability, and reproduction is minimal.

Incubation period – The time interval between egg laying and hatching.

Indigenous species – Naturally occurring species of native or local origination (i.e. not imported or introduced.

Iteroparous – Species capable of breeding more than once in their lifetime.

Juvenile – Young fish, older than one year, fundamentally like adults in appearance, but smaller and reproductively inactive.

Lacustrine habitat – Habitat contained within a pond or lake.

Landlocked – Populations of fish that are prevented from making return migrations to the ocean because of natural obstructions. It also categorizes fish that live their entire life cycle within freshwater regardless of whether they have access to the ocean.

Larvae – Organisms which at birth or hatching are fundamentally unlike their parents and must pass through metamorphosis before assuming adult characteristics.

Lentic – Refers to standing water, as in ponds and lakes.

Limnetic – Open-water regions, either middle or surface water levels, that are not directly influenced by the shore or bottom.

Littoral – The marginal region of a body of water and is usually defined by the band from zero depth to the maximum depth of light penetration. Often this area is shallow, subject to fluctuating water temperatures and erosion of shore material through wave action and the grinding of ice.

Lotic – Flowing water.

Macrophytes – Rooted aquatic plants.

Metamorphosis – Change in form and structure which fish undergo from the embryo to adult stages.

Migration – The deliberate movement of fish from one habitat to another.

Natal river – The river or stream in which a fish was spawned.

Native species – Fish that originate in the area in which they live (refer to indigenous species).

Nursery (Rearing) habitat – The portion of fish habitat which provides food and cover for young fish.

Oligotrophic – Condition of water being poor in plant nutrients.

Ontogenetic – Size-related shifts of life history changes that occur during the growth and development of an individual.

Organic – Derived from a living organism.

Organic debris – Material in a water course that is of organic origin including algae, aquatic plants, logs, trees, and other woody material.

Overhanging (Riparian) cover – Cover provided by vegetation such as grasses, shrubs, alders and other low-story trees adjacent to the waterbody and up to 1 m above the water surface.

Overhead cover – Riparian cover overhanging littoral habitat, woody debris at the surface providing shade, crevices etc.

Piscivorous – Fish-eating.

Plankton – Small aquatic plants and animals, sometimes microscopic, drifting within the surrounding water.

Population – A group of individuals of a species occupying the same waters during at least part of their life cycle.

Potamodromous – Fish which exhibit a migratory behavior within freshwater habitats, usually manifested as spawning in smaller tributary streams and rearing in lakes or rivers.

Profundal – The deep, cold region of lakes where currents are at a minimum and where light is much reduced, comprises the deep water and the lake bottom.

Redd – The nest of salmonid fishes where the eggs are deposited.

Resident fish – Fish which remain in freshwater throughout their entire life cycle (non-anadromous).

Semelparous – Species capable of breeding only once in their lifetime.

Shoal – Offshore shallow areas.

Silt – Very fine sediment particles that can be carried or moved by stream currents and deposited in slower moving water. This material is particularly harmful to invertebrates and extremely detrimental to spawning habitat.

Smolt – A salmonid having undergone physiological changes to cope with shifting from freshwater to a marine environment, usually refers to salmonids exhibiting silvery coloration and downstream movement to the ocean.

Spawning habitat – Habitat used by reproductively active fish for spawning and incubation of fertilized eggs.

Submergent vegetation – Aquatic plants that grow entirely below the water's surface (e.g. pondweeds, bladderwort) and includes numerous mosses and macroalgae.

Substrate – The materials of which a stream or lake bottom is comprised including, bedrock, boulder, rubble, cobble, gravel, sand, silt, detritus and mud.

Sympatric – Species inhabiting the same or overlapping geographic areas and are not denied the opportunity to breed by any geographic barrier.

Threatened species – Indigenous taxa that are likely to become endangered, if factors affecting their vulnerability are not reversed (Cannings and Ptolemy 1998).

Tributary – Refers to any stream that flows into another, larger stream above its confluence with saltwater, or a lake (river mouth).

Upwelling – The motion or movement of water in the upward direction.

Vulnerable species – indigenous species that are not immediately threatened but are particularly at risk for reasons including low or declining abundance, a restricted distribution or occurrence at the fringe of their global range (Cannings and Ptolemy 1998).

Watershed – A region or area bounded peripherally by a water parting and draining ultimately to a particular watercourse or body of water.

Young-of-the-year – Essentially the first year of life for a fish (age 0+).